2.4 Research and Development Portfolio

Our Research Portfolio includes the following research projects categorized by the primary Strategic Goal addressed. Each project is described in subsequent pages:

Strategic Goal 1 - Respiratory diseases: Reduce respiratory diseases in miners by reducing health hazards in the workplace associated with coal worker pneumoconiosis, silicosis, and diesel emissions.

Research Projects:

1. Assessment of Personal Particulate Exposure
2. Characterizing Diesel Emissions in Underground Mines
3. Advanced Spray Dust Capture Principles for Mine Dust Control
4. Control of Silica Dust Exposures in Underground Coal Mining
5. Dust Control for Longwall Mining
6. Improving Ventilation Technology in Large Opening Mines
7. Miners´ Response to Personal Dust Monitor Feedback
8. Coal Workers' Health Surveillance Program (CWHSP)
9. Reducing Underground Miners´ Exposure to Diesel Emissions
10. Selection and Evaluation of Diesel Emission Controls for Outby Underground Coal Mine Equipment
11. A Cohort Mortality Study With A Nested Case-Control Study Of Lung Cancer And Diesel Exhaust Among Non-Metal Miners
12. Silica Dust Control in Metal/Nonmetal Mining
13. Surface Mine Dust Control
14. Ultrafine Aerosols From Diesel-Powered Equipment

Strategic Goal 2 - Hearing loss: Reduce noise-induced hearing loss (NIHL) in the mining industry.

Research Projects:

1. A Health Hazard Study of Surface Drilling Operations
2. Cross-Sectional Survey: Noise Exposure Patterns/Sources
3. Definition and Assessment of Engineering Noise Controls
4. Engineering Noise Controls for Roof Bolting Machines
5. Health Communication Interventions for Hearing Loss Prevention
6. Hearing Loss Prevention: Hearing Protection and Audibility Considerations
7. Pilot Study on Coal Cutting Noise Related to Continuous Mining Machines

Strategic Goal 3 - Cumulative injuries: Reduce repetitive/cumulative musculoskeletal injuries in mine workers.

Research Projects:

1. Ergonomics Evaluation and Improvement of Mobile Equipment
2. Ergonomics Process Effectiveness in Mining
3. Reduce Injury & MSD Risk from Human-Machine Interaction
4. Successful Aging for Miners Through Ergonomics (SAME)

Strategic Goal 4 - Traumatic injuries: Reduce traumatic injuries in the mining workplace.

Research Projects:

1. Evaluating Roadway Construction Work Zone Interventions
2. Lockout/Tagout, Jammed, and Moving Machinery Controls
3. Mobile Mining Equipment Warning Systems
4. Protocol for Evaluating Quality of Explosives in the Field
5. Reducing Electric Arc-Induced Injuries in Mining
6. Remotely-Controlled Bulldozer on Coal Stockpiles
7. Safety Enhancements for Off-Road Haulage Trucks
8. Safety Solutions to Prevent Mining Materials-Handling Accidents
9. Smart Wearables for Hazardous Work Environments
10. Surface Blasting Safety and Health
11. Virtual Reality for Mine Safety Training

Strategic Goal 5 - Mine disasters: Reduce the risk of mine disasters (fires, explosions, and inundations); and minimize the risk to, and enhance the effectiveness of, emergency responders.

Research Projects:

1. CCER Standard
2. Coal Mine Face Methane Control and Monitoring
3. Design Guidelines for Mine Ventilation Stoppings
4. Fire Hazard Reduction in the Metal and Nonmetal Mining Industry
5. Investigation of Methane Control Issues in Underground Mines
6. Lake Lynn Laboratory
7. Long Term Field Evaluation (LTFE)
8. Mine Rescue and Response
9. Prevention and Mitigation of Gas/Dust Explosions
10. Prevention and Mitigation of Mine Inundations
11. Reducing Fire Hazards in U.S. Coal Mines
12. Remote Methods for Addressing Coal Mine Fires
13. SCSR Training Modules
14. Smoke Management and Fire Modeling for Underground Mines

Strategic Goal 6 - Ground control: Reduce ground failure fatalities and injuries in the mining industry.

Research Projects:

1. Development and Evaluation of Innovative Roof Support Technologies
2. Fragmentation Methods and Ground Control Safety
3. Fundamental Studies of Factors Responsible for Falls of Ground
4. Ground Stability Through Advanced Mine Design
5. Guidelines for Eliminating Hazardous Ground Conditions From Underground Stone Mines
6. Identification and Control of Rock Burst Hazards
7. Preventing Injuries from Falling Rock in Underground Coal Mines
8. Reduce Groundfall Hazards in Nevada
9. Roof Fall Evaluation and Mediation in Weak Rocks
10. Slope Stability Hazards Recognition
11. Stability Assessment with Seismic Monitoring

Strategic Goal 7 - Surveillance and training: Determine the impact of changing mining conditions, new and emerging technologies, training, and the changing patterns of work on worker health and safety.

Research Projects:

1. Chemical Hazards in Coal Mining
2. Chemical Hazards in Mining
3. Disseminating Safety and Health Interventions Via the Internet
4. Education and Training for an Evolving Mining Work Force
5. Evaluation of Heat Stress and Interventions in Surface and Underground Mines
6. Hazard Evaluation and Technical Assistance
7. Health Communications Program
8. Surveillance of Mine Safety Hazards
9. Surveillance: National Survey of the Mining Population
10. Workplace Stress Among Underground Coal Miners

Ongoing Research Project related to Respiratory Diseases

Assessment of Personal Particulate Exposure

PURPOSE: Reduce respirable dust-related health concerns by developing portable, mine-worthy devices capable of providing timely measurement of coal and silica dust, diesel aerosols, and other airborne contaminants.

RESEARCH SUMMARY: Assessment of workplace exposure to particulate matter is a critical step in eliminating dust-related occupational illness and disease. During 1990-99, coal workers´ pneumoconiosis caused the deaths of 15,036 U.S. miners. Between 1987 and 1996, silicosis, excluding carcinomas potentially caused by silica, prematurely shortened Americans' lives by 33,000 years. In 1988, NIOSH recommended that whole diesel exhaust be regarded as a potential occupational carcinogen.

Current industrial hygiene particulate assessment methods do not provide timely data to an industry with a workplace as dynamic and unique as mining. The intent of this project is to study and develop various tools that can be used to assess mineworker exposure to airborne particulate. Real-time measurement tools will enable workers and management to take corrective action before dust levels can affect workers' health.

Two specific devices are in development. A mine-worthy and accurate personal dust monitor (PDM) has been designed and built based on a tapered element oscillating microbalance, an inertial-oriented, momentum compensated mass sensor. The PDM meets the NIOSH accuracy criteria and provides timely data to miners wearing the unit. Laboratory evaluations of this device are completed and field trials are well along. New Mine Safety and Health Administration rules regarding compliance-based underground dust measurements are on hold pending the outcome of this research. A fast, accurate, and economic method to measure diesel exhaust particulate has also been developed, based upon the NIOSH-patented dust dosimeter. It relies on the measurement of increased differential pressure across a filter that is inserted into an engine tailpipe. The Australian government is considering rulemaking involving the adoption of this device into their mines.

Personal Dust Monitor provides data to miners in time to take action to prevent overexposures

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
mining, assessment, coal, silica, diesel

Acceptance by regulatory agencies, miners, and industry personnel of the instruments developed will make it more likely that particulate levels are maintained within acceptable limits. The successful outcome of the work will result in new tools and approaches to particulate monitoring, designed to protect worker health. These technical advancements will be transferred to industry through mine visits, briefings, conference presentations, and formal and informal workshops.

Ongoing Research Project related to Respiratory Diseases

Characterizing Diesel Emissions in Underground Mines

PURPOSE: Protect miners working in underground mines from diesel-powered equipment emissions through improvements in diesel particulate emission measurement techniques.

RESEARCH SUMMARY: Long-term exposure to elevated concentrations of diesel exhaust has become a concern because diesel particulate matter (DPM) is considered to be a carcinogen by several organizations. Approximately 30,000 underground miners are exposed to excessively high DPM concentrations (greater than 500 g/m3). Since DPM consists of over 80% total carbon (TC), the Mine Safety and Health Administration (MSHA) initially chose TC as the surrogate for DPM. TC is the sum of organic carbon (OC) and elemental carbon (EC) fractions. The problem with TC is the number of other TC sources, besides DPM, in the mining environment. Research has shown that these TC interferences, such as mineral dust and vapor-phase OC, can be eliminated or corrected, but airborne contaminants like, cigarette smoke and oil mist, cannot.

Sampling package for DPM field measurements

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
diesel, air monitoring, aerosols, ultrafines, real time

In light of the problem with TC interferences, EC, with NIOSH influence, has become the surrogate for DPM. The problem with EC as a surrogate is that the relationship between EC and total DPM can change, depending on engine duty cycle and other factors.

Because of programmatic effort, several notable outcomes have been accomplished. MSHA has changed the DPM concentration surrogate from TC to EC. This change allows MSHA personnel to take interference-free samples to more accurately evaluate miner exposures. DPM cassettes, designed through Bureau of Mines/NIOSH research and manufactured by SKC, Inc., have become the standard DPM sampling technique. MSHA, industry, and labor have agreed on an interim DPM exposure limit. Finally, the underground mining industry, labor, and government have created a partnership to address issues relative to DPM exposure.

Several other diesel emission monitoring problems related to miner health exist that are being studied under this project. The relationship between EC and total DPM must be investigated, especially as new emission control technologies are implemented. Novel methods for determining and characterizing diesel emissions need to be developed. Finally, the industry is in need of a device that will enable personnel to determine real-time DPM concentrations in the mining environment

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Ongoing Research Project related to Respiratory Diseases

Advanced Spray Dust Capture Principles for Mine Dust Control

PURPOSE: The objective of this research is to reduce mine worker exposure to respirable coal and/or silica dust by increasing the dust capture efficiency of mine water spray systems.

Dust generated from rotary cutting saw at a dimension stone shop

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
silica, coal mine dust, mining, control technology

RESEARCH SUMMARY: Coal workers´ pneumoconiosis (CWP) and silicosis are debilitating and sometimes fatal occupational lung diseases that afflict mine workers at underground and surface mining operations. The number of mining deaths between 1990 and 1999 related to CWP was 15,036. From 1990 to 1999, there were 2,405 deaths related to silicosis. For 880 of the silicosis deaths, the associated industries were recorded on the death certificates with 203 (23.1%) attributed to coal and metal/nonmetal mining combined. For this same time period, the percentage of coal mine dust samples that exceeded the 2.0 mg/m^3 dust standard was nearly 9%, while the percentage of dust samples exceeding the allowable silica limit for coal, metal, and nonmetal mining were 30%, 12%, and 7%, respectively. These data illustrate the severity of lung disease in mining and the inadequacy of control technologies for consistently maintaining compliance with the mandated dust standards.

Laboratory tests have been completed to quantify the air moving capability of different spray nozzles, as well as, the dust capture efficiency of these sprays for multiple operating pressures. This information was used to develop a water-powered scrubber that moves approximately 500 cfm of air with a high dust capture efficiency, yet operates at water pressures below 250 psi.

Future research will focus on using this fundamental spray characteristics knowledge to improve existing dust control systems and/or develop new control applications. Laboratory research work for improving the dust capture efficiency of coal mining machine mounted spray systems is planned for future testing in the full scale dust gallery. Successful technologies will then be tested at operating mine sites. Recently, arrangements have been made to conduct a dust survey in early spring at a dimension stone shop to evaluate a water-powered scrubber. This scrubber will be installed to evaluate its effectiveness for reducing silica dust generated by a rock cutting saw.

Planned project outcomes are to develop and demonstrate improved, user-oriented, spray systems for mining and cutting machines that can reduce airborne respirable dust by more than 30%. A measure of project outcomes would be to have these spray system developments adopted or implemented in a notable segment (30%) of the mining industry within 5 years of project completion.

Ongoing Research Project related to Respiratory Diseases

Control of Silica Dust Exposures in Underground Coal Mining

PURPOSE: Develop controls that reduce silica dust exposures for operators of continuous mining machines and roof bolting machines to prevent the development of silicosis.

Canopy air curtain installed on roof bolter in underground coal mine

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
silica, dust, underground mining, control technology

RESEARCH SUMMARY: In underground coal mines, the two occupations with the highest risk of excessive exposure to respirable silica dust are the continuous mining machine operator and the roof bolter operator. The Mine Safety and Health Administration (MSHA) analyzed nearly 31,000 personal samples for these occupations during the period 1999-2003. Nearly 12% of these samples exceeded the federal dust standard of 2 $\mu g/m^3$ while 20% of these samples exceeded a silica dust concentration of 100 $\mu g/m^3$; the maximum allowed under MSHA regulations. Overexposures continue to occur with miners still contracting coal workers´ pneumoconiosis and silicosis, both debilitating and fatal lung diseases.

To lower the silica dust exposures of roof bolter operators, NIOSH developed a canopy air curtain that reduced dust levels under the air curtain by approximately 50% in laboratory testing. The canopy air curtain was modified for retrofit onto a roof bolter and tested at an operating underground mine. Results indicate that dust levels for the operator working beneath the drilling canopy were reduced but not to the level found in the lab. NIOSH is working with the bolter manufacturer and mine operator to modify the size and flow characteristics of the tested air curtain to improve its dust reduction potential and application to other bolting machines.

Wet head continuous miners introduce water via sprays located behind each cutting bit on the cutting drum instead of via a spray bar positioned back from the cutting drum. This places sprays closer to the cutting with the potential to reduce airborne dust levels. NIOSH has completed an evaluation of a wet head miner that was operated with exhaust curtain ventilation. Some improvements in dust levels at the operator were measured. Future studies are planned to evaluate wet head technology for miners that are operated with blowing face ventilation.

Airflow from the dust scrubber on the continuous miner can be redirected to the face through a series of louvers in an attempt to contain and capture more of the dust generated at the face, thus reducing the dust exposure of the miner operator. NIOSH worked with a coal company to test redirected scrubber flow. Results showed that the dust exposure of the shuttle car operators was reduced over 50%. The impact on the exposure of the miner operator was much less, indicating

a need to research and optimize the balance between the redirected scrubber flow and the face ventilation flow. Laboratory tests will be completed to develop guidelines regarding the use of redirected scrubber exhaust for control of respirable dust, with special attention given to balancing redirected and primary airflows.

Ongoing Research Project related to Respiratory Diseases

Dust Control for Longwall Mining

PURPOSE: The objective of this research project is to lower the risk of developing debilitating lung diseases by reducing respirable dust exposure to mine workers at longwall mining operations.

Conducting dust sampling on longwall face

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
coal mine dust, underground mining, control technology

RESEARCH SUMMARY: Longwall mining operations now account for approximately 51% of the coal produced underground in the United States. Unfortunately, substantial increases in coal extraction rates also result in the generation of more respirable dust. From 1996 through 2000, compliance dust samples exceeding the federal dust standard of 2.0 mg/m3 were 18% and 15% for jack setters and shearer operators, respectively. Health surveillance data also indicates that overexposure to respirable dust in underground coal mines continues to lead to the development of lung disease.

Laboratory research has been conducted to evaluate and optimize control parameters that impact dust generated by the shearer. These results provide operators with guidance on dust control resulting from changes in face air velocity, water spray pressure, water quantity, spray system design and cutting direction. Additional laboratory testing will be conducted to optimize external sprays system designs for high coal operations.

Laboratory testing has also been completed to evaluate shield dust entrainment in high velocity airstreams up to 2000 fpm. Results have shown that significant increases in respirable dust levels were observed as air velocity increased. Future tests will evaluate the ability of water sprays to reduce respirable dust entrainment in these high velocity airstreams.

Benchmarking surveys have been conducted on six longwall faces across the country to quantify dust levels from various sources, define current operating practices, and determine the relative effectiveness of existing control technologies. Four additional surveys will be completed and a "best practices" document produced to assist operators in applying effective control technologies.

Successful completion of this research project will result in developing improved dust control technologies/practices that can be adopted by longwall operators throughout the United States. The goal is to reduce dust exposure of longwall mine workers by 30% over a 5-year period as these controls are implemented.

Ongoing Research Project related to Respiratory Diseases

Improving Ventilation Technology in Large Opening Mines

PURPOSE: To improve the air quality in metal/nonmetal mines to reduce the risk of adverse health effects from worker exposure to airborne contaminants such as diesel particulate matter (DPM), toxic fumes from blasting, and silica dust.

Propeller fans installed for main mine ventilation in a large opening stone mine

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
underground mining, ventilation, diesel, airborne contaminants

RESEARCH SUMMARY: Virtually all underground stone mines and many other metal/nonmetal mines have large openings creating ventilation airflows with low velocities. Due to the ventilation inefficiencies common to these mines, the underground workers are exposed to a variety of potentially harmful substances through the air they breathe. Reductions in worker exposure to these contaminants can be achieved by improving the ventilation airflow in these mines. These goals are particularly timely in that the metal/nonmetal mining industry is confronted with new DPM regulatory exposure limits that were set forth in 2002, with more stringent restrictions scheduled to take place in 2006.

Practical methods to improve ventilation airflows in large opening mines are being investigated. Several methods have been conceived, developed, and evaluated in operating large opening stone mines that have been shown to improve the general air quality in the underground workplace. These methods include: (1) identifying the proper fans for use in large opening mines; (2) including ventilation needs as an integral part of the mine planning process to aid the development and use of efficient generic ventilation designs for all mines; (3) developing a computer program to determine the approximate air flow volume necessary to meet statutory air quality (DPM) requirements based on the diesel equipment in use at an individual mine site; and (4) improving the construction methods and materials used to construct stoppings for directing mine ventilation air to the critical areas of large opening mines to reduce worker exposure to airborne contaminants.

Although there have been many general improvements in large opening mine ventilation practices resulting from the current research effort, the current state of the technology for addressing very site specific contamination areas in large opening mines is still the random and unscientific placement of auxiliary ventilation fans in the working areas. Additional research will develop optimum methods for getting higher volumes of non-contaminated mine ventilation air to the working areas, i.e., increasing the ventilation efficiency. This will be accomplished by developing novel mining

methods to direct the ventilation airflow to the working areas, including the use of using long stone pillars and auxiliary fans. At the conclusion of the research effort, Best Practices for improving ventilation airflow in large opening mines will be made available to the metal/nonmetal mining industry to reduce workers exposure to airborne contaminates in large opening mines.

Ongoing Research Project related to Respiratory Diseases

Miners´ Response to Personal Dust Monitor Feedback

PURPOSE: To document how coal miners can use real-time information from their personal dust monitors (PDM) to reduce their exposure to respirable dust.

Interview with coal miner concerning his understanding and utilization of new PDM

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
coal miners, pneumoconiosis, mine safety and health, lung diseases

RESEARCH SUMMARY: Although the most recent data on the prevalence of Coal Workers' Pneumoconiosis (CWP) in the United States indicates that it is declining, substantial numbers of CWP cases continue to be diagnosed. In recent years, CWP has contributed to the deaths of approximately 1,000 people in the U.S. each year. A PDM has recently been developed via a NIOSH contract with Rupprecht & Patashnick Co., Inc. As with the introduction of any new technology, it is very important to systematically document how workers react to it and make use of it. It is hoped that miners will use the real time dust exposure information provided by their PDM to make adjustments to their work place or work procedures that reduce their exposure to respirable dust. However, no one knows precisely how miners performing a wide variety of tasks and jobs are actually going to make use of this new information. This study will ensure that the strategies miners discover for using PDM information are well documented and quickly shared throughout the coal industry. The information for this study will be collected through one-on-one structured interviews with approximately 20 miners at each of 5 mines located throughout the major coal producing regions of the U.S. A structured interview guide has been developed and pilot tested at two mines. This study will help reduce the incidence of lung disease among coal miners, leading to improvements in their longevity and quality of life. The outputs of this project will include publications and presentations on how coal miners can use information from PDMs to reduce their exposure to respirable dust. Also, materials will be developed for (a) teaching miners about the capabilities and use of their PDM, and (b) teaching PDM maintenance personnel about how to download data, clean the unit, and program it for the next shift of sampling.

Ongoing Research Project related to Respiratory Diseases

Coal Workers' Health Surveillance Program (CWHSP)

PURPOSE: The Federal Coal Mine Health and Safety Act of 1969 (as amended by the Federal Mine Safety and Health Act of 1977) is intended to protect the health and safety of underground coal miners. The Act authorizes a program for early detection and prevention of coal workers' pneumoconiosis carried out by NIOSH in cooperation with the Mine Safety and Health Administration (MSHA). These activities are specified in the Federal Regulations, 42 CFR 37, "Specifications for Medical Examinations of Underground Coal Miners" and are administered through the Coal Workers' Health Surveillance Program (CWHSP).

Mobile Occupational Safety and Health Unit

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
coal miners, coal workers´ pneumoconiosis, silicosis, pneumoconiosis, chest x-rays, surveillance, B-Readers

RESEARCH SUMMARY: The CWHSP includes: certification of x-ray facilities; training, testing, and certification of physician readers (B Readers); classification of chest radiographs for pneumoconiosis; communication of individual examination results to miners; notification to miners with evidence of pneumoconiosis about options to transfer to low dust areas (Part 90); and provision of data to evaluate the respiratory health of underground coal miners. The CWHSP maintains a radiographic examination data base utilized by NIOSH for surveillance purposes and by researchers involved in developing strategies to reduce the incidence and progression of coal workers' pneumoconiosis.

During the early 1970s, one of every three miners examined in the program who had worked at least 25 years underground had radiographic evidence of pneumoconiosis. A recent analysis of over 25,000 miners who were examined from 1996 to 2002 indicates that the proportion of underground coal miners affected has greatly decreased, to about one in 20. However, recent analyses (including novel analyses of disease progression) also suggests that certain groups of miners - those who work in certain mining jobs, in smaller mines, in several geographic areas, and among contract miners - remain at elevated risk. These new findings are driving targeted assessments and preventive interventions, making more effective use of CWHSP data than has previously been done. A recent extension of the CWHSP, implemented by NIOSH in cooperation with MSHA, has been helpful in highlighting the continuing occurrence of pneumoconiosis among surface coal miners, who have not been eligible for the ongoing radiographic examination program mandated by Federal law.

Starting in FY06, in collaboration with MSHA, CWHSP enhancements will be implemented. A recently acquired Mobile Occupational Safety and Health Unit (see photo) is expected to help increase miner participation in programs for early detection of dust-related lung disease. Results are intended to facilitate preventive actions, through the derivation of representative current estimates of the burden, distribution, and determinants of occupational lung disease in relation to coal mining in the U.S.

Ongoing Research Project related to Respiratory Diseases

Reducing Underground Miners´ Exposure to Diesel Emissions

PURPOSE: Reduce diesel exhaust gas and particulate matter levels in underground mines by providing scientific and technical data on the effects of available and novel control technologies measured by both established and experimental methods.

NIOSH Mobile Engine Dynamometer

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
mining, diesel, control technology, methods development

RESEARCH SUMMARY: Approximately 30,000 underground miners have been found to be exposed to diesel particulate matter (DPM) at levels as high as 500 µg/m3. Promulgation of regulations by the Mine Safety and Health Administration (MSHA), limiting exposure of coal, metal, and nonmetal underground miners to DPM, is resulting in a rapid implementation of various novel technologies for control of DPM and gaseous emissions. Many of these emission control technologies have been evaluated under highly controlled laboratory conditions that are not representative of real-use conditions. The effectiveness of these technologies in the mine environment has a direct consequence on the success of the rule to control miner exposures to DPM.

Recognizing this situation, NIOSH has responded by conducting in-mine evaluations of many of these control technologies and by developing a unique research facility to supply this critical knowledge. A research lab has been established at the NIOSH Lake Lynn Laboratory which employs a mobile engine dynamometer. It is operated under tightly controlled conditions, yet the exhaust is released into the prevailing ventilation as is the case in mining, resulting in obtaining near-laboratory-quality data under operating conditions.

Several major controlled in mine evaluations of various control technologies have been evaluated and the information disseminated to the industry. Currently, at the Lake Lynn Lab, tests are being conducted to determine the effects on DPM concentrations by a control technology that uses water to cool the exhaust and follows that with a disposable pleated element filter, as is the practice in coal mines. The testing of other more novel emission control technologies will follow. As it matures, this program will amend itself to find answers to real-world concerns regarding miner health and emission control.

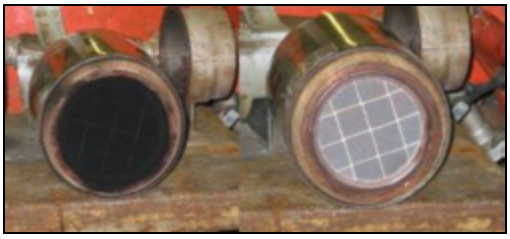
The plan is to publish and present Lake Lynn Laboratory work and production mine study results in peer-reviewed journals, at conferences, at mining community meetings, and at workshops organized through the NIOSH partnerships with both coal and the metal/nonmetal mining industry.

Ongoing Research Project related to Respiratory Diseases

Selection and Evaluation of Diesel Emission Controls for Outby Underground Coal Mine Equipment

PURPOSE: Provide the mining industry, labor, and regulatory agencies with scientific, technical, and engineering research on controlling of diesel particulate matter (DPM) and gaseous emissions through laboratory and field evaluations of existing and emerging control technologies.

RESEARCH SUMMARY: Approximately 30,000 underground miners have been exposed to DPM at levels as high as 500 µg/m3, an excessively high level. The publication of a Mine Safety and Health Administration (MSHA) proposed rule to regulate underground miner exposure to DPM, along with a NIOSH initiative, has resulted in the formation of a coal partnership for the purpose of investigating, testing, and promoting effective control technologies. The success of the coal partnership, resulted in the metal/nonmetal industry also forming a partnership with NIOSH that also continues to be supported under this project.



Evidence of the effectiveness of a DPM filter

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
mining, diesel, airborne contaminants

Emission control technologies are evaluated on a mobile engine dynamometer at the NIOSH Lake Lynn Laboratory and at mine field sites provided by the partnerships. This work includes; 1) the selection of potentially viable emission controls, 2) resolving issues related to their use, and 3) information dissemination and education to facilitate their implementation in mines.

This project is also introducing modern clean engine technology into underground mines. The engine subcommittee of the coal partnership, headed by NIOSH, is actively engaged in devising a policy that will permit the use of insulating materials to supplement water-jacketing so that modern clean engines can be used in permissible power packages.

This effort has provided real-world emissions-reduction data for a number of filter media and fuel formulations through laboratory and isolated zone studies in operating mines. The quality of this work has earned both high praise and respect from our constituents and has allowed us to forge new initiatives.

Modern, super-clean, electronically controlled engines are accepted at high altitude western coal mines. A recent outcome of high altitude research involves a mining operation´s decision to replace 54 diesel-powered trucks with vehicles having new low-emitting engines. This resulted from NIOSH recommendations that led an engine manufacturer to develop a new control module, enabling use at high altitude mines.

Ongoing Research Project related to Respiratory Diseases

A Cohort Mortality Study With A Nested Case-Control Study Of Lung Cancer And Diesel Exhaust Among Non-Metal Miners

PURPOSE: The retrospective cohort mortality and nested case control study is investigating risk of lung cancer in relation to quantitative measures of exposure to diesel exhaust. In addition, it will determine whether there is evidence of elevated mortality from other causes among miners exposed to diesel exhaust.

RESEARCH SUMMARY: The mortality study cohort of about 10,000 miners comprises all non-office workers from eight selected mines who were employed for at least one year during the period from the date of dieselization at the mine until the end of follow up on December 31, 1997. A standard mortality ratio analysis will be undertaken, overall and by level of diesel exhaust exposure. Poisson regression and Cox proportional hazard modeling of mortality will be carried out using exposures derived from the exposure assessment phase of the project.

Workers in a underground non-metal mine

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
mining, diesel exhaust, mortality, lung cancer

The nested case control study is based on deaths from lung cancer ascertained during the follow up stage of the cohort study. Four controls will be selected for each case from among members of the cohort who were alive at the time that the case died, matching on mine, year of birth, gender, and race/ethnicity. Information on smoking (active and passive) and other potential confounders (e.g., employment in high risk occupations for lung cancer, diet, and certain medical conditions) will be ascertained by interview of next of kin of deceased cases and controls and direct interview of living controls. Conditional logistic regression will be used to determine risk of mortality from lung cancer for various measures of diesel exhaust exposure, including cumulative exposure and average intensity.

Information from comprehensive industrial hygiene surveys at each working mine, together with past exposure and surrogate data, will be used to construct estimates of personal exposure for input into the cohort and case control studies. The measurements include elemental carbon (currently considered the most specific measure of general diesel exhaust exposure), submicrometer combustible dust, submicrometer particulate, the organic fraction of the exhaust, NO, NO^2, CO, CO^2, nitro-polycyclic aromatic hydrocarbons (nitro PAHs) and respirable and total particulate. Information on the operating and organizational structure of each mine, together with the sampling results, will be used to define uniform exposure categories (either job based or zone based). This information will be combined with data on significant change

periods to develop a matrix of exposure levels by exposure category (zone or job). Then, by employing an exposure category/job dictionary and the job history for each person, individual exposure estimates will be developed. More detailed exposure information will be collected for each subject in the nested case control study in order to refine the exposure estimates.

Ongoing Research Project related to Respiratory Diseases

Silica Dust Control in Metal/Nonmetal Mining

PURPOSE: Reduce worker exposure to respirable silica dust in metal/nonmetal operations by developing improved control technologies.

RESEARCH SUMMARY: Chronic overexposure to respirable crystalline silica can lead to the progressive lung disease known as silicosis, which can be disabling or fatal. Data in the Mine Safety and Health Administration´s (MSHA) compliance sampling database indicates that a significant percentage of both underground and surface metal/nonmetal miners are overexposed to respirable silica dust each year. For samples collected from 2001 through 2004, 12% of all samples exceeded the permissible exposure limit (PEL), with numerous high-risk occupations having over 20% of their samples exceeding the PEL. This research program will conduct field surveys to identify dust sources for these high risk occupations, develop control technologies through laboratory and/or field studies, and transfer successful technologies to stakeholders.

Worker using Clothes Cleaning Process to remove dust

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
silica, control technology, underground mining, surface mining

To date, research has been conducted to: 1) develop optimized pressurization and filtration systems for enclosed cabs on mobile mining equipment and associated implementation guidelines, 2) develop a cost-effective method for cleaning work clothes in an enclosed booth and associated instructional video, 3) evaluate existing dust controls and develop improved ventilation controls for iron ore processing plants, and 4) demonstrate the effectiveness of improved mine-wide and localized ventilation systems in limestone mines for diluting dust and reducing residence time.

Future research will address: 1) the development and testing of control technologies to reduce worker exposure to silica dust in dimension stone shops, 2) the development of a stand-alone, clothes cleaning booth, which will increase its application in the industry 3) the benchmarking of controls for the silica sand industry and preparation of a handbook through a cooperative effort with Industrial Minerals Association - North America, and 4) the identifying of major dust sources for mobile workers to develop controls to reduce these exposures.

Successful outcomes will be measured by the effectiveness of the control technologies to lower exposure to respirable silica dust and the willingness of industry to adopt these control technologies at their mines and processing plants. A measure of this success would be a 50% reduction in the silica compliance samples for high risk occupations that exceed the permissible exposure limits over a five year time period.

Ongoing Research Project related to Respiratory Diseases

Surface Mine Dust Control

PURPOSE: The objective of this project is to improve the understanding of dust generation principles, evaluate and improve current control technologies, and develop new control technologies to provide a broad-based approach towards reducing silica exposure in surface mining operations.

Dust sampling on a surface mine drill

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
surface mining, dust, silica, control technology

RESEARCH SUMMARY: Historically, Mine Safety and Health Administration (MSHA) dust sampling data has indicated that some of the most frequently overexposed mining occupations are at surface coal mines. MSHA data for the years 1996 through 2000, shows that of the 1,400 respirable dust samples collected on highwall drill operators at surface mines, over 31% exceeded the permissible exposure limit (PEL) for silica dust.

Reducing respirable silica dust exposures to surface mine workers will be accomplished through multiple efforts. A number of research tasks will address dust generated by surface drills, which is typically the greatest dust source at surface mine sites. Respirable dust reductions for surface drills will be achieved through application of engineering controls that include: using air spray nozzles to maximize dust capture under the drill shroud, developing methods to reduce/eliminate dust emissions at the dust collector´s discharge dump, determining the optimum drilling parameters for minimizing respirable dust generation and using wet drilling technology to reduce dust liberation. Testing will be conducted with full-scale test facilities located at PRL to determine optimum system parameters for using air spray nozzles. Successful lab results will lead to evaluation at working surface mine sites.

Most surface mining equipment is equipped with enclosed cabs that have the potential to provide significant protection from respirable dust, if properly operating. Cab research has focused on improving the performance of air filtration and air conditioning/heating systems. Enclosed cab integrity will be addressed by determining the effective range of operating parameters (filter loading and system integrity) and identifying effective cab maintenance guidelines. In addition, a field-test method for evaluating environmental integrity of enclosed cab systems has been developed and tested through a cooperative research and development agreement (CRADA) with a filter manufacturer. Method development is ongoing and a patent is being pursued. Demonstration of these improved dust control technologies will be completed at a limited number of mining operations.

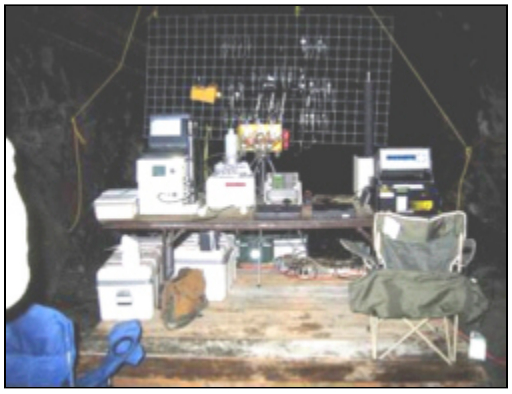
This research program has the potential to lower the silica exposure of workers by reducing dust generation during drilling and by improving the protection offered by enclosed cabs. Successful development and implementation of improved control technologies will lead to reducing overexposures by 30% within the next five years.

Ongoing Research Project related to Respiratory Diseases

Ultrafine Aerosols From Diesel-Powered Equipment

PURPOSE: Formulate control technologies to reduce miner exposure and determine associated occupational health risks through the identification of nanometer and ultrafine aerosols emitted by diesel-powered equipment.

RESEARCH SUMMARY: More than 30,000 underground miners have been found to be exposed to diesel particulate matter (DPM) at levels as high as 500 $\mu g/m^3$, an exceedingly high value. Recent promulgation of regulations by the Mine Safety and Health Administration (MSHA), limiting DPM exposures of underground miners, resulted in a swift implementation of novel technologies to control DPM and gaseous emissions. Control technologies, as well as modern diesel engines, were found to fundamentally change the physical, chemical, and toxicological properties of the emitted solid and gaseous aerosols. It is important to understand what these emissions are before prescribing solutions to control them.



Sampling diesel emissions in an underground mine

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STRATEGIC GOAL:
Respiratory diseases

KEYWORDS:
exposure, diesel, control technology

In determining particle toxicity, past research has demonstrated the importance of parameters such as size, number, solubility, and surface area and chemistry. The effects that control technologies have on the physical and chemical properties and toxicity of nanometer and ultrafine diesel aerosols will be studied in a series of tests with the NIOSH Mobile Engine Dynamometer, both at the NIOSH Lake Lynn Laboratory experimental mine and at participating active mines. State-of-the-art instrumentation will be used to directly measure size distribution and number of nanometer and ultrafine aerosols. The chemical composition of these aerosols will be determined from the collected samples using proven analytical techniques. Genotoxicity analyses, performed by the NIOSH Health Effects Laboratory Division, will investigate the effects of control technologies on nanometer and ultrafine aerosol toxicity.

Results will provide industry, labor, and enforcement agencies with a better understanding of the physical and chemical properties and toxicity of diesel-generated nanometer and ultrafine aerosols. They will assess the effects that these properties have on workers´ health, particularly asthmatic and chronic obstructive pulmonary diseases. Researchers will generate information on the effects of various control technologies and modern diesel engines on the characteristics of

aerosols and gases in mine air. These outputs should also result in a more sensitive, accurate, and relevant metric for monitoring the exposure of workers to DPM emissions. Ultimately, the industry´s acceptance of appropriately designed control technologies will reduce mineworkers´ exposure to nanometer and ultrafine aerosols.

Ongoing Research Project related to Hearing Loss

A Health Hazard Study of Surface Drilling Operations

PURPOSE: Develop engineering noise controls and a basis for hierarchical recommendations from a noise exposure analysis (NEA) to protect drill operators from hearing loss on non-cab surface drill rigs.

RESEARCH SUMMARY: Noise induced hearing loss (NIHL) is the most common occupational disease in the United States today, with 30 million workers exposed to excessive noise levels (NIOSH, NORA 1996). Further, NIOSH data indicates that at least 70% of mine workers (also engaged in drilling activities) suffer noise induced hearing loss severe enough to be classified as a hearing disability. There are similar equipment and working conditions that exist at surface drilling sites (water well, construction) which suggest that operators at these locations may also be overexposed. Recent data collected during the period of 2000-2002 by the PRL Hearing Loss Prevention Mobile Unit shows that most surface drilling professionals over the age of 40 have a noise induced hearing loss according to the 1998 NIOSH criterion.

Surface drill rig without any engineering noise controls

This project concentrates on reducing excessive noise exposures to operators and helpers on various drill rigs that lack noise control devices. Attention to drill operator´s location and activities will lead to the development of an affordable, universally fitted, protective device that protects the operator from over exposure to noise, thus filling the gap between engineering controls, administrative controls, and personal protective equipment. This information can be used to generate educational or training materials to reduce over-exposure to noise while performing surface drilling activities.

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STRATEGIC GOAL:
Hearing loss

KEYWORDS:
drilling, noise, noise induced hearing loss, hearing loss prevention

Currently researchers are in the process of developing a partial cab that can be attached to drill rigs without a cab. The partial cab has three sides to enable the operator easy access to the drill steel while still offering protection from high sound levels. In laboratory tests, the researchers identified the construction of the partial cab that would yield the highest noise reduction while keeping cost to a minimum. Results of the laboratory tests show that the reductions in the

A-weighted sound level ranged from approximately 8 to 15 dB. The Development of a Noise Exposure Analysis (NEA) database for all the field data parameters has been completed. Field site investigations were conducted at eight field sites. Every field site investigation included measuring the drill operator´s noise exposure and documenting a corresponding time-motion, (job activity) study. Findings in the database will be used to evaluate the interdependence between work practices and noise exposure levels.

The outputs and outcomes for this research are as follows: A prototype partial cab will be fabricated and attached to test rigs. Controlled tests will be conducted to ensure testing parameters in the prototype design are confirmed. Field testing of the partial cab in productive environments will then be performed at several sites to confirm the efficiency of the partial cab to reduce operator´s noise exposure levels. The NEA results will be used to develop multiple training products. They will be industry specific and focus on the work practices that have the highest noise exposure levels. These training products will be disseminated to industry representatives through conference presentations, publications and future field work with industry partners.

Ongoing Research Project related to Hearing Loss

Cross-Sectional Survey: Noise Exposure Patterns/Sources

PURPOSE: To establish representative noise exposure profiles for the various mining occupations, equipment noise levels, and characterize the exposure/source relationship.

RESEARCH SUMMARY: Noise-induced hearing loss (NIHL) is recognized by NIOSH in the NORA document as the most common occupational disease in the United States. Despite the progress achieved over the last 2 decades, overexposure to noise in the mining workplace remains a serious problem for mine workers. Every day, 80% of the Nation´s miners go to work in an environment where the time-weighted average (TWA) noise level exceeds 85 dB(A); even worse, 25% of the miners are exposed to a TWA noise level that exceeds 90 dB(A). Several studies have shown that by age 50, 90% of miners have a hearing impairment. Recent noise exposure data collected in the coal industry during project surveys indicate that nearly 50% of workers were exposed to noise levels above 90 dB(A), with some exposures nearly 6 times the permissible exposure level. Clearly, a need exists for research to ensure that the hearing of miners will be preserved.

NIOSH engineers conducting a noise survey in a dragline

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STRATEGIC GOAL:
Hearing loss

KEYWORDS:
hearing loss, research, exposure assessment

Surveillance is seen as one of the fundamental keys to this effort. The collection of baseline information that will provide a current and improved characterization of worker noise exposure patterns and mining noise sources is essential to develop effective intervention strategies for preventing hearing loss. The baseline line data will consist of worker noise dose, task observations to relate source to dose, and equipment noise profiles. It is anticipated that 5 to 10 mines and plants will be surveyed each year, with 45 to 50 mines and plants total surveyed by project end in 2007. The mining sectors investigated will include coal, stone, and sand and gravel.

Results to date indicate that upwards of 40% of all workers monitored were subject to noise exposures above 90 dB(A) TWA_8. In the underground coal mines, the percentage is nearly twice as high for workers directly involved with the extraction of coal at the mine face. The data also reveals that the underground coal extraction equipment is among the noisiest equipment used in mining and is the primary contributors to worker overexposures.

The expected outputs of this research are updated data bases of equipment noise and worker noise exposures in all sectors of mining. The outcomes include a more comprehensive understanding of the noise environment in the mining industry and a more effective selection and application of both engineering and administrative controls for reducing worker noise exposures.

Ongoing Research Project related to Hearing Loss

Definition and Assessment of Engineering Noise Controls

PURPOSE: To document and evaluate noise control technologies that are used in or applicable to the mining and construction industries and then expand this base of information to other industries. Also, to understand the noise generating mechanisms to aid in the development of new noise control technology.

RESEARCH SUMMARY: Noise induced hearing loss is the most common occupational illness in the United States today, with over 30 million workers exposed to excessive noise levels. Engineering control of noise is the long-term solution to the nation´s occupational hearing loss problem. However, in the mining industry the application of engineered noise controls has been fraught with problems. An important enabling step for the application of existing control technology, or the development of new technology, is the identification of existing controls and their effectiveness.

Researchers measure and record the sound level in the cab of an idling haul truck

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STRATEGIC GOAL:
Hearing loss

KEYWORDS:
noise, control technology, sound level, hearing conservation

The measurement of engineering noise control effectiveness is done by acquiring acoustic data with and without the control in place. The measured acoustic parameters include sound pressure level, sound intensity level, and percent noise dose. If a control cannot be removed from an application, an effort is made to find a machine of similar make, model, and age without the treatment in place. In addition to being used to evaluate the effectiveness of an engineering noise control, sound intensity measurements are applicable for noise source location. Once the primary noise sources are identified, engineering controls can be more effectively implemented.

Over the course of this study it was learned that many mine operators install noise controls without knowing how much noise reduction to expect from a control before installation, or how much noise reduction is actually achieved after the control is installed. Also, it was found that in some cases acoustical materials were improperly used. As a result of this research, increased emphasis has been placed on the installation of proven noise controls as opposed to the ´try this, try that´ approach to noise control that was common in the past.

The majority of the outputs for this project has and will be numerous reports, presentations, and publications documenting the effective and ineffective noise controls on existing mining equipment. The ultimate outcome of this research is to educate mine operators and equipment manufacturers on not only which engineering noise controls are successful, but a basic understanding in noise control techniques which will aid them in developing their own application of controls for their future noise reduction efforts.

Ongoing Research Project related to Hearing Loss

Engineering Noise Controls for Roof Bolting Machines

PURPOSE: The objective of this project is to determine and implement appropriate engineering controls to reduce excessive exposure to noise on the job and prevent additional cases of Noise Induced Hearing Loss (NIHL) related to roof bolting machine operators.

RESEARCH SUMMARY: Noise is one of the most pervasive health hazards in mining. The National Institute for Occupational Safety and Health has identified occupational NIHL as one of the ten leading work-related diseases and injuries. MSHA coal noise samples from 2000 to 2002 show that 65% of the equipment whose operators´ noise dosage exceeded 100% is comprised of seven different types of machines: auger miners, bulldozers, continuous miners, front end loaders, roof bolting machines, shuttle cars (electric), and trucks. Of these, the roof bolting machine was the third most common type of equipment whose operators exceeded 100% dosage.

Roof bolting machine in the PRL Reverberation Chamber

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STRATEGIC GOAL:
Hearing loss

KEYWORDS:
mining, roof bolting machines, noise dose, sound power, noise induced hearing loss, hearing loss prevention

The relationship of noise generated by the drilling and bolting cycles of a roof bolting machine utilized in underground coal mining and the attributed noise exposure of the operator will be investigated. A noise survey of roof bolting machine operators will be conducted to identify the tasks which are significant contributors to the operator´s noise exposure. This will be accomplished by placing a dosimeter on the operator to record his noise exposure while simultaneously conducting a time-motion or task observation. The drilling and bolting duty cycles will be extracted from the data to determine how much noise exposure to the operator is generated by these individual tasks. Sound power measurements will then be conducted on the roof bolting machine in the PRL reverberation chamber, along with above ground measurements in a free-field noise environment. Additionally, underground measurements will be performed using a sound level meter to record the sound levels of the roof bolting machine thru several duty cycles. The data will be analyzed to assess the relationship of the drilling and bolting cycles to the noise exposure associated to the operator. Noise sources will be identified and ranked according to their percentage of contribution to the overall sound level generated by the drilling and bolting cycles.

From this, NIOSH will develop and test conceptual engineering controls designed to reduce the noise emission of roof bolting machines and thus, reduce the noise dosage exposure and NIHL of their operators. This information will be disseminated to the mining industry for their use in retrofitting existing equipment and as an aid for a quiet-by-design approach for developing the next generation of equipment.

Ongoing Research Project related to Hearing Loss

Health Communication Interventions for Hearing Loss Prevention

PURPOSE: To develop more effective communication and training techniques and products that give workers the motivation and skills to prevent hearing loss.

RESEARCH SUMMARY: This 3-year project, now in its final year, is showing workers how to take a more effective role in preventing hearing loss by reducing their exposure to hazardous noise. Findings from tests conducted with the Hearing Loss Prevention Unit mobile research facility indicate that 31% of the miners had a hearing impairment, a percentage that grows to 50% for miners in their 50s. A major obstacle to reducing these rates is the ineffective use of noise controls and protective devices. For instance NIOSH research on sand and gravel miners has shown usage rates of hearing protectors to be below 50%.

Miners participating in an earplug effectiveness test

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STRATEGIC GOAL:
Hearing loss

KEYWORDS:
communication, hearing loss, prevention, training, web site

This issue is being addressed though a variety of health communications techniques. The first step is to increase workers´ motivation to take effective action, and then provide these motivated workers with the knowledge and skills they need to reduce their noise exposure and protect their hearing. Specific problematic attitudes and behaviors with each health communication study are being targeted. An example would be the widespread myth that most hearing loss is a natural consequence of aging.

A Hearing Loss Simulator was developed, and its ability to motivate workers to avoid hazardous noise and protect their hearing better was studied. This Windows-based program demonstrates the "sound" of a hearing loss that results from a hypothetical noise dose set by the user. Trainees can immediately hear the muffled speech and almost-inaudible industrial warning sounds as heard "through" a hearing impairment. Trainees who heard the simulator had significantly improved knowledge about the causes and results of hearing loss, and were more motivated to take preventive action. To investigate improving knowledge and skills, a simplified "Roll-Pull-Hold" technique for the types of foam earplugs that are widely used for hearing protection was developed and evaluated. When workers followed a simple three-step procedure, their earplugs sealed their ear canals better and reduced the level of noise reaching their eardrums by an average of 9 decibels.

The simulator was released on CD-ROM and now has hundreds of users and supporting organizations that include the Mine Safety and Health Administration (MSHA), the Council for Accreditation in Occupational Hearing Conservation (CAOHC), and the National Hearing Conservation Association (NHCA). The Roll-Pull-Hold technique is being disseminated through an instructional page and 1-minute video clip on the NIOSH website. The short-term benefits of these communications interventions are expected to result in long-term exposure and hearing loss reductions, and plans are being made to conduct a long-term evaluation in a follow-on project.

Ongoing Research Project related to Hearing Loss

Hearing Loss Prevention: Hearing Protection and Audibility Considerations

PURPOSE: To develop recommendations and strategies for mine operators and mineworkers that will improve the audibility of spoken communication and hazard/warning signals in the mining environment while preventing additional cases of noise-induced hearing loss.

RESEARCH SUMMARY: Hearing protection devices are still needed in many settings where engineering and administrative controls are insufficient to reduce noise to a safe level. However, workers have reported significant concerns about the diminished audibility of speech, machine alarms, and other important sounds that result from wearing standard hearing protectors. By addressing this concern, this study will encourage the use of hearing protection in ways that minimize audibility problems.

Human subject testing of new hearing protector systems

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STRATEGIC GOAL:
Hearing loss

KEYWORDS:
noise, hearing loss, hearing protectors

There are hundreds of different hearing protectors on the market, including standard earmuffs, earplugs, and sophisticated electronic designs. Every protector has a different effect on the types of sounds they allow to reach the wearer´s ears, and the spatial cues they provide about the location of sound sources. Current research is quantifying these effects so appropriate recommendations can be made for different occupational noise environments.

Along with standard hearing protectors, new technological approaches to protection and exposure reduction are also being investigated. For instance, extensive laboratory evaluations of protectors that use electronic systems to pass selected sounds through the protector are being performed. A system that uses microphones inside the protector to provide feedback about the noise levels that actually reach the wearer´s ears was also recently evaluated. In general, the microphone placements used in this system potentially provided a usable approximation of the wearer´s true dosage.

Ongoing Research Project related to Hearing Loss

Pilot Study on Coal Cutting Noise Related to Continuous Mining Machines

PURPOSE: To determine the significance of cutting noise relative to the noise exposure of continuous mining machine operators.

RESEARCH SUMMARY: Noise-induced hearing loss is (NIHL) is the most common occupational disease in the country. Despite 25 years of regulation, a recent NIOSH study showed that at age 51 approximately 90% of coal miners and 49% of metal/non-metal miners had a hearing impairment whereas only 10% of the non-occupational-noise exposed population had a hearing impairment. MSHA Coal Noise Data collected from 2000 to 2002 shows that 65% of the workers who were overexposed to noise operated one of seven types of equipment. Of these seven types of machines, continuous mining machines had the most noise overexposures, accounting for 35% of all noise overexposures.

A continuous mining machine cutting head

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STRATEGIC GOAL:
Hearing loss

KEYWORDS:
noise, control technology, mining, equipment

The noise generated by a continuous mining machine is primarily due to three sources: the conveyor, the dust scrubber, and the cutting drum. Prior NIOSH projects have developed noise controls to reduce the sound levels generated by the conveyor and dust scrubber on continuous mining machines. However, the noise associated with cutting coal has not been addressed. This effort will focus on determining the significance of coal cutting noise to the noise exposure of continuous mining machine operators. The hypothesis is that cutting coal is a major contributor to the operator´s noise exposure. Sound levels near the continuous mining machine operator will be measured in mines while cutting and conveying coal. These sound levels will be analyzed to determine the worker noise exposure associated with each process.

NIOSH will determine if cutting noise is a significant contributor to the operator´s noise exposure. If so then candidate engineering control concepts would be evaluated and the promising concepts will be recommended for development and implementation.

Upon completion of this one year pilot study, the results will be published in a peer-reviewed journal and presented at the appropriate mining conferences. The results of the project will provide a direction for the development of engineering noise controls to reduce continuous mining machine operator noise exposure. If cutting noise is found to be significant, noise controls must be developed to reduce the sound levels generated by cutting coal. However, if cutting noise is found to be insignificant, the future direction of noise control development for continuous mining machines would then be focused on additional noise controls to address conveyor noise.

Ongoing Research Project related to Cumulative Injuries

Ergonomics Evaluation and Improvement of Mobile Equipment

PURPOSE: Reduce musculoskeletal disorders among operators of mobile equipment.

RESEARCH SUMMARY: A recent estimate shows there are approximately 540,000 operators of heavy equipment (i.e., dozers, loaders, haul trucks, etc.) in mining and construction in the United States and this number is expected to increase. Operators of mobile equipment perform various duties that expose them to a variety of risk factors in the work environment, such as whole-body vibration, awkward postural requirements, repetitive motions, poor seat design, and poorly designed cabs or controls, all of which have the potential to cause injury and expose operators to the risk of developing musculoskeletal disorders. Musculoskeletal disorders - including most sprains and strains - are the most common type of nonfatal injury in mining. In addition, loss of postural stability and improper egress are significant factors in fall injuries among these operators.

A dump truck at a construction site in Iowa

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STRATEGIC GOAL:
Cumulative injuries

KEYWORDS:
mining, construction, ergonomics, vibration, musculoskeletal disorders

Mine Safety and Health Administration (MSHA) data show that between 1999 and 2003, 4079 accidents in surface mining were classified as back injuries and contributed to nearly 173,000 lost or restricted work days (an average of 42 days lost or restricted per accident). Truck drivers (n = 535), dozer operators (n = 467), and front-end loader operators (n = 409) alone accounted for over one-third of these injuries. Another 6060 accidents during this same period were classified as injuries caused by overexertion and affected truck drivers (n = 539), dozer operators (n = 508), and front-end loader operators (n = 358).

The specific aims of this project are to (1) evaluate the ergonomic design of cabs and egress from and entry into cabs, (2) estimate the landing force required to exit mobile equipment, (3) characterize exposure to whole-body vibration at the seat/operator interface; (4) evaluate the effects of whole-body vibration on operators´ postural stability; and (5) collect work and health questionnaire data from operators of heavy mobile equipment as part of an epidemiological survey.

Some of the significant outcomes will be (1) field tests of the effectiveness of a device to reduce low back discomfort among operators of mobile equipment, (2) evaluations of cab design of mobile equipment, (3) a better understanding of the prevalence of musculoskeletal symptoms and psychosocial factors affecting operators of construction equipment, (4) evaluations of postural stability after exposure to whole-body vibration and development of recommendations for control, and (5) evaluations of landing forces as operators exit equipment and development of recommendations for control.

Ongoing Research Project related to Cumulative Injuries

Ergonomics Process Effectiveness in Mining

PURPOSE: To demonstrate ergonomics processes can effectively lower worker exposure to musculoskeletal disorder (MSD) risk factors and reduce MSD incident rates in mining environments.

RESEARCH SUMMARY: An analysis of National Occupational Health Survey of Mining (NOHSM) data showed that exposures to ergonomic risk factors for mine workers were high compared to those in non-mining occupations. Another study utilizing NOHSM data reported that at least 35% of mine workers were potentially exposed to musculoskeletal overload conditions. There have also been many studies providing evidence that well-designed ergonomics processes can improve working conditions and worker health and safety. A recently completed NIOSH project demonstrated the benefits of implementing an ergonomics process at a surface coal mine. Unlike other studies, this project established that an ergonomics process could be implemented in harsh and dynamic environments found in mining.

This mechanic is using an employee-designed support for an impact wrench. Use of the support has substantially reduced exposures to ergonomic risk factors.

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STRATEGIC GOAL:
Cumulative injuries

KEYWORDS:
mining, ergonomics, musculoskeletal disorders

During this study, researchers will continue to partner with mining companies to implement and evaluate ergonomics processes. Through communication and demonstration, partnerships with trade associations will promote the implementation of effective ergonomics processes to their members. How organizations implement ergonomics can vary widely, depending in part on organizational size, work culture, and mining methods. Similarly, relevant measures for evaluating process effectiveness also vary widely. A key element to this study will be to create a metric to assess the developmental stage of a process as well as its effectiveness. Additionally, researchers plan to (1) initiate and evaluate ergonomics processes at two or more mine sites, (2) compile recommendations for effectively applying ergonomic principles to mining work methods and equipment designs, and (3) develop and evaluate training modules that are necessary to establish, maintain, and grow an effective process. To date, PRL researchers have assisted a surface sandstone mine with integrating an ergonomics process with their existing safety and health program, have partnered with the Industrial Minerals Association - North America to raise the awareness level of its members on how ergonomics can be used to reduce MSD incident rates, and have developed task-specific interventions for dragline workstations.

The long-term goal of this study will be to reduce MSD incident rates in mining work environments. Demonstration of effective ways to proactively apply ergonomic principles to mining work activities will promote their use by the mining community.

Ongoing Research Project related to Cumulative Injuries

Reduce Injury & MSD Risk from Human-Machine Interaction

PURPOSE: To reduce mine injuries, work-related musculoskeletal disorders (MSDs), and accidents through studies of roof bolter, continuous miner and load-haul-dump (LHD) machine designs and operator tasks.

RESEARCH SUMMARY: MSHA injury data from 2000 to 2004 indicates that two of the major sources of injuries in underground mining came from powered machinery and MSDs. For the same reporting period, almost one third of all incidents could be classified as MSD related. Powered machinery comprised almost 42% of the injuries and 62% of the fatalities. Further analysis showed that the two most frequent causes of machinery related accidents were tramming equipment (roof bolters 19% and continuous miners 6%) and jarring and jolting (load-haul- dumps (LHD´s)/scoops and mantrips 14%).

This research consists of four parts: roof bolter appendage speed study, roof bolter operator low back stress analysis, machine tramming study, and jarring/jolting study of (LHD)/scoops & personnel carrier seats. These provide recommendations/interventions for reducing both the underground mine work hazards and MSDs. Mine work hazards and MSDs arise from improperly designed workstations, equipment, and/or work methods. These include machine and human-body appendage impact, operator errors, awkward postures, repetitive and forceful motions, and excessive jarring and jolting.

Top Left - Roof bolter boom arm swing data collection; Top Right - Operator low back stress computer simulations; Bottom Left - Machine tram and visual cue simulations; Bottom Right - Vehicle seat test set up to collect vibration data

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STRATEGIC GOAL:
Cumulative injuries

KEYWORDS:
mining injury prevention, traumatic injuries; MSD, whole body vibration, safe machine designs

Vertical and horizontal appendage speeds for a roof bolter are evaluated and recommendations for machine design modifications and job-task procedural changes that maximize the operator´s chances of escaping injury from contacting a moving boom arm are provided. Initial analysis of low back stress experienced by roof bolter operators showed that an operator´s standing posture, compared to a kneeling posture, significantly increases the forward bending moment, compression force and trunk muscle activity. Also, the kneeling postures in a 45-inch seam height, compared to a 60-inch seam height, increase the same muscle activity significantly for lateral movements and torso extension. Using computer models and operator job task analysis, a risk assessment methodology, detailing the relative risk from each of

the environmental hazards that affect their safety, is being developed for face equipment workers. For seated workers in LHD/scoops and personnel carriers vibration studies will be conducted to recommending engineering controls and/or ergonomic interventions for reducing the jarring/jolting related injuries.

Ongoing Research Project related to Cumulative Injuries

Successful Aging for Miners Through Ergonomics (SAME)

PURPOSE: Through the use of training programs and engineering interventions, to promote successful aging and reduce the risk of musculoskeletal injury for all ages of workers in the mining industry.

RESEARCH SUMMARY: Workers employed in the mining industry have historically been involved in physically demanding work, and as a group they are older than workers in general industry. The Bureau of Labor Statistics (2004) estimated that the median age of the coal mine worker in 2004 was 45.9 years old while the median age overall for the U.S. employee was 40.5 years. These statistics indicate that a substantial section of the mining workforce may have started experiencing the normal physical changes that accompany aging, such as reduced strength and flexibility, decreases in contrast sensitivity and dark adaptation, and reduced aerobic capacity.

Percentage of Injuries that are Musculoskeletal by Age of Mine Worker, 1992-2002

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STRATEGIC GOAL:
Cumulative injuries

KEYWORDS:
aging worker, mining, ergonomics, back injury, slips/falls

Project SAME focuses exclusively on using ergonomics to mediate age-related physical changes in mine workers and promote safer working procedures for all ages of employees. Stakeholder input and analysis of MSHA injury data indicate that the following highest priority areas should be targeted:

- Intervention efforts must target all ages of employees with the intent of limiting musculoskeletal injuries to our older workers and preventing musculoskeletal injuries in our younger workers. To address this issue, our prevention efforts will include the development of a training program to increase awareness of the changes that occur with the normal aging process and to learn how to mediate those changes through job re-design.
- The back is the most frequently affected part of the body, back injuries often re-occur with age, and back injuries tend to be more expensive than injuries that occur to other parts of the body. We are developing a better tool to assess the risk of back injury in miners and allow for effective engineering interventions.
- Slips and falls tend to occur more frequently in older workers, and they are often more severe for older workers; slips and falls can occur while walking or while getting on or off a piece of equipment. We are approaching this problem in a multi-faceted manner and plan to provide the mining industry with better suggestions for boot design, work procedures, and safer methods for ingress and egress from equipment.

We have learned that with increasing worker age come greater percentages of MSDs, more recurrent back injuries, and more slips and falls. Expected outcomes include the reduction in the percentage of MSDs with increasing age and also a reduction of MSDs for back injuries and slips and falls. Interventions from this project are applicable to industries such as construction and agriculture.

Ongoing Research Project related to Traumatic Injuries

Evaluating Roadway Construction Work Zone Interventions

PURPOSE: To develop a practical worker warning device called HASARD (Hazardous Area Signaling and Ranging Device) that industry can license and to design and construct a Work Zone Analysis System (WZAS) for recording and quantifying worker exposure around moving vehicles and equipment.

NIOSH researchers collecting data associated with a road paving project . The Work Zone Analysis System (WZAS) is being used to record multi-camera video and GPS data.

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
traumatic injuries, mining, construction, vehicles, hazards

RESEARCH SUMMARY: According to MSHA statistics an average of 13 miners are killed each year by being run over or pinned by mobile mining equipment. At surface mines, these accidents frequently involve large dump trucks that drive over a smaller vehicle or a worker that is in a blind spot of the truck. Over 50% of these accidents could have been avoided if the equipment operator had been adequately warned of the impending collision. In addition, highway and street construction workers are at risk of fatal and serious nonfatal injury when working near passing motorists, construction vehicles and equipment. During 1992-98, 841 highway and street construction workers were fatally injured. In 465 (55%) of these cases the death was either vehicle- or equipment-related and, most likely occurred in the work zone. In 318 of the 465 (68%) fatalities within work zones, a worker on foot was struck by a vehicle. Victims were as likely to be struck by a construction vehicle as by a passing traffic vehicle. The HASARD system has been developed to warn workers of their proximity to potentially dangerous areas around moving equipment. It has been thoroughly tested in the laboratory and is now ready for commercial licensing. A second patent on this device was granted in October 2004. Three companies have recently obtained user-development licenses and three other companies have applied for licenses and one CRADA. The WZAS was completed in May 2004 and is now being used to collect multi-camera video and GPS data at field sites. An Open Industry Briefing on "Proximity Warning Systems for Surface Mining and Roadway Construction" is currently planned to occur toward the end of 2006. A set of guidelines, for use by the surface mining and roadway construction industries, on how to implement the HASARD system on haulage trucks will also be developed by then. Both fatalities and injuries due to workers being run over or pinned by haul trucks, surface mining equipment, and roadway construction equipment are expected to significantly decline wherever this technology is successfully implemented. Also, this type of proximity warning system could be readily modified for helping to protect workers in other industries such as underground mining, manufacturing, agriculture, construction, and forestry.

Ongoing Research Project related to Traumatic Injuries

Lockout/Tagout, Jammed, and Moving Machinery Controls

PURPOSE: To develop a practical device to warn workers, especially maintenance personnel required to lock and tag out equipment, of their proximity to potentially hazardous areas around moving equipment.

The HASARD system is being field tested on a moving belt conveyor. The white cylinder in the center of the photo is the HASARD transmitting antenna.

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
traumatic injuries, mining, haulage, engineering

RESEARCH SUMMARY: Lockout/tagout (LOTO), required by OSHA Standard 29 CFR 1910.147, is a protective procedure workers must perform to remove hazardous energy from machinery prior to performing maintenance tasks. All energy sources for equipment must be de-energized and the switch locked and labeled with a tag warning not to activate the machinery. Lockout/tagout violations consistently rank in the top five of OSHA's most frequently cited standards. The National Stone, Sand & Gravel Association lists LOTO as one of the most important safety issues facing the aggregate industry. Belt conveyor injuries (over 400/year) have historically ranked among the most severe in the mining industry according to MSHA. Fatalities resulting from workers being caught in machinery average 150 per year, with about half related to service- or maintenance tasks. Serious nonfatal injuries from being caught in machinery, average 6800/year and are the leading cause of amputations among workers. The HASARD proximity warning device has the potential to warn workers of danger prior to conducting maintenance. It has been developed and tested in the laboratory and is ready for commercial licensing. A second U. S. patent (#6,810,353) on this device was granted in October 2004. Three companies have recently obtained user-development licenses and three other companies have applied for licenses and one CRADA. An Open Industry Briefing on proximity warning systems for underground and surface mining will be held at PRL towards the end of 2005. The project ends in 2005. A set of guidelines on how to implement the HASARD technology on remote-control continuous mining machines will be disseminated to the mining community in 2006. Both fatalities and injuries due to workers becoming caught in moving conveyors and mining machinery are expected to significantly decline wherever this technology is successfully implemented. This type of proximity warning system could be readily modified to protect workers in industries other than mining such as construction and agriculture.

Ongoing Research Project related to Traumatic Injuries

Mobile Mining Equipment Warning Systems

PURPOSE: Reduce the number of injuries and deaths of workers who operate or work near lift trucks at mining operations.

Instrumented lift truck with operator warning system being test driven at proving grounds

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
mine safety, warning system, rollover, control technology, lift trucks

RESEARCH SUMMARY: A common danger in the mining, agriculture, and construction industries occurs when mobile equipment is unknowingly operated in an unsafe manner. Operator errors are frequently the result of inadequate training, complacency regarding equipment operation, and taking shortcuts. Many times an operator unknowingly operates the equipment beyond its safe operating limits or fails to recognize dangers in the work environment. Unsafe operation can result in injuries and deaths of both drivers and pedestrian workers; over 100 fatalities and 20,000 forklift injuries occur yearly in the United States. Seventy percent of these accidents were caused by operator error. In 2000, the leading causes of lift truck fatalities were lift truck overturns (23%), pedestrians and workers struck by lift trucks (39%), and falls from lift trucks (10%). During 1999-2003, over 355 lift truck accidents occurred at mining operations.

Researchers from the Spokane Research Laboratory (SRL), in collaboration with the North American Coal Company (NACCO), are investigating ways to reduce the high number of injuries and deaths related to dangerous lift truck operating practices. Specific questions being addressed are (1) what are the critical operating parameters that should be monitored to prevent rollovers, collisions, and operator errors? (2) what instruments are available that could be used to monitor these parameters? and (3) what is the most effective way to alert an operator to unsafe operating and environmental conditions?

A lift truck is being retrofitted with an electronic monitoring system that continuously monitors critical operating parameters (i.e., pitch, roll, payload, lift height, loading dock edge, nearby objects) of a lift truck to determine if the vehicle is being operated safely. When a critical operating parameter is exceeded, a digital voice warning message is activated that can be heard by both the lift truck operator and any nearby workers. It can, for example, alert the operator when he or she is traveling or cornering too fast, lifting too heavy a load, or approaching the edge of a loading dock. The sensor-based monitoring system can also be used as a tool to improve lift truck operator training, evaluate training programs, and identify areas in need of additional safety training.

Field tests of the instrumented lift truck were conducted on NACCO´s proving grounds in Fairview, OR, to determine the effectiveness of the 40 installed instruments and the data acquisition system in preparation for in-depth field tests at a commercial site. The technology being developed in this project can be applied to a wide variety of other types of mobile mining and construction equipment to alert an operator or nearby workers to dangerous operating conditions and practices.

Ongoing Research Project related to Traumatic Injuries

Protocol for Evaluating Quality of Explosives in the Field

PURPOSE: The purpose of this project is to develop a suite of protocols that a blaster or mine inspector can use in the field to determine if a high explosive, blasting agent, or emulsion oxidizer are of a poor quality that could lead to an accident.

PRL technician pours kerosene on the wood cribbing in preparation for the Heavy Confinement Pipe Bomb test. When the fire is ignited, the 100 lb of material in the steel bomb will be heated to the point where it either burns off or explodes.

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
blasting, explosives, mining

RESEARCH SUMMARY: The explosive manufacturing business is currently very competitive. Manufactures must hold down cost of their products to maintain their share of the market. In this effort to hold down costs for explosive manufacture, quality control may suffer. With poor quality control, an explosive that is classified by DOT as a blasting agent may in reality be a high explosive. Transportation and storage requirements for high explosives are more stringent than those for the less sensitive blasting agents. Treating a high explosive as a blasting agent could lead to serious accidents. Alternatively, if a high explosive is too insensitive due to a manufacturing error, misfires will result. Protocols for evaluating the safety of explosives currently exist, but for all practical purposes these tests cannot be conducted in the field if a blaster or inspector has concerns about the quality of the blasting agent or explosive being used. PRL is developing a simplified protocol for evaluating explosive quality, and hence safety. This will not be a replacement for the original, extensive protocols. The simplified protocol will be a screening test to detect the most common hazards related to explosive quality. There will necessarily be a tradeoff between the complexity of the protocol and the ability to identify hazards. Preliminary results suggest that tests to determine detonation velocity, explosive density, and detonability by a blasting cap are practical for conduct in the field and will go a long way towards verifying whether an explosive is performing as expected. Upon completion of this project, blasters will have a way to verify that an explosive will shoot as expected, before it can result in a poor blast that would have serious safety ramifications.

Partners/collaborator in the project is the Mine Safety and Health Administration.

Ongoing Research Project related to Traumatic Injuries

Reducing Electric Arc-Induced Injuries in Mining

PURPOSE: To reduce the number and severity of electric arc burn injuries in mining.

RESEARCH SUMMARY: Systematic electric arc protection for industrial workers is specified by the National Electrical Code (NFPA 70) and the NFPA Standard for Electrical Safety in the Workplace (NFPA 70E). The scopes of NFPA 70 and NFPA 70E specifically exclude the underground mining industry due to its unique electrical needs and problems. 30CFR Parts 56, 57, 75, and 77 contain mining electrical safety provisions, but 30CFR does not require anything beyond rudimentary PPE for hazardous underground electrical maintenance work. Between 1990 and 2003, 2,326 traumatic mine electrical injuries occurred. The largest single category of electrical injury was burns from electrical arcing, which accounted for 893 (38%) of all electrical injuries. Electrical burn injuries of all types accounted for more than 21,500 lost work days. The project approach focuses on the development of a comprehensive program of engineering analysis and controls, management of work activities, training, and the use of personal protective equipment (PPE). Computer simulations are employed to estimate the arcing fault energy available from the power systems of representative mine and mineral processing plants. The systems selected represent the most dangerous mining industry sectors. Simulation results will allow the definition of boundaries or zones where protection from arc-flashes is needed for various equipment and circumstances. Findings thus far indicate a general lack of awareness of common arc-flash hazards in the mining industry. Accident reports show that two-thirds of arc-flash injuries involve circuit breakers, cables, hand tools, meters, and plugs. The equipment and PPE needed for safe troubleshooting in arc-prone situations are seldom used. Circuit breakers are often operated beyond their design parameters and many are repaired by third-party rebuilders using substandard components. Power system coordination is seldom optimum. Thirty-one victims of, or witnesses to, arc burn accidents have been interviewed. Victims now realize that their understanding of arc-flash hazards was inadequate. Many see their failure to wear arc-rated clothing, face and hand protection, use appropriate tools and

This 480-volt fused disconnect switch was recently involved in an arcing fault accident. The resulting explosion burned two experienced miners who were investigating a problem.

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
electrical, burn, traumatic injuries, training

meters, and work on live circuits as unsafe work practices that need to be altered by improved hazard recognition training. This project will produce practical guidelines to determine arc flash boundaries in mines and prep plants. Recommended improvements in work practices regarding the use of hand tools, meters, PPE, and other engineering controls will increase miners´ understanding of arc-flash hazards. Training guidelines will show how to most effectively present this information to the mining audience. Follow-on work will implement the guidelines as 10-minute and 30-minute training modules available to MSHA trainers. It is envisioned that the outcome of hazard recognition training, PPE, and improved work practices would be a dramatic reduction in the number and severity of arc-flash injuries in mining.

Ongoing Research Project related to Traumatic Injuries

Remotely-Controlled Bulldozer on Coal Stockpiles

PURPOSE: To improve the safety associated with the operation of bulldozers on coal stockpiles by investigating the feasibility of remote-control operation.

Voids in coal stockpiles can entrap bulldozer operators

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
hazards, mining, vehicles

RESEARCH SUMMARY: Environmental conditions, coal compaction, and other factors can result in voids in coal stockpiles which can entrap bulldozers used to facilitate drawdown at the top of the piles. Since 1980, there have been 19 fatalities at coal stockpiles, the majority being bulldozer operators. Efforts by MSHA and others have led to development of improved cab designs, high strength windows, and communications which have proven to save operator lives during dozer cover-ups. Providing remote control of the dozer has the potential to totally eliminate the danger to the operator by removing him/her from the machine. Previous attempts to remotely control the dozer were never fully implemented due to a variety of issues. One drawback was that the operator, when removed from the dozer, lost the feel of the machine due to time lags in the controls. This resulted in significant inefficiencies during remote operation compared with on-board control. Addressing this issue, NIOSH has developed a new approach to remote-control which can closely mimic the feel of the machine for the operator by adding visual, audio, and vibratory cues. Both MSHA and ConsolEnergy have expressed a need for this work. The overall objective of this new project would be achieved through several phases. Phase I would investigate the feasibility of using a 360-degree camera installed on a dozer to provide visual feedback to the remote operator. This camera would continuously transmit a panoramic image to a receiver at the operator location. The machine operator, equipped with a head-mounted sensor that tracks head movement, would view an image that one would see if actually operating the machine. Dozer movements would be wirelessly controlled via joysticks at the industrial remote-control station using drive-by-wire technology with virtually instantaneous response. In conjunction with this feedback, a stereo sound system would replicate dozer audio in real time. The success of this initial phase would warrant a follow-up (Phase II) investigation to further refine and improve machine remote operation. Here, the feasibility of using a motion table to provide feedback of machine movement to the remote operator would be investigated. Such a system would use accelerometers on the bulldozer to sense movement. This data would be transmitted back to the remote operator seated on a motion pod incorporating six-degrees of freedom. Thus the pod would simulate and record machine movements. The anticipated

outcome of a successful demonstration of a remotely-operated dozer would, in the long term, be an increased adoption of this method for stockpiles in mining. This development would result in a reduction in incidents and fatalities from dozer cover-ups by removing the dozer operator from the stockpile.

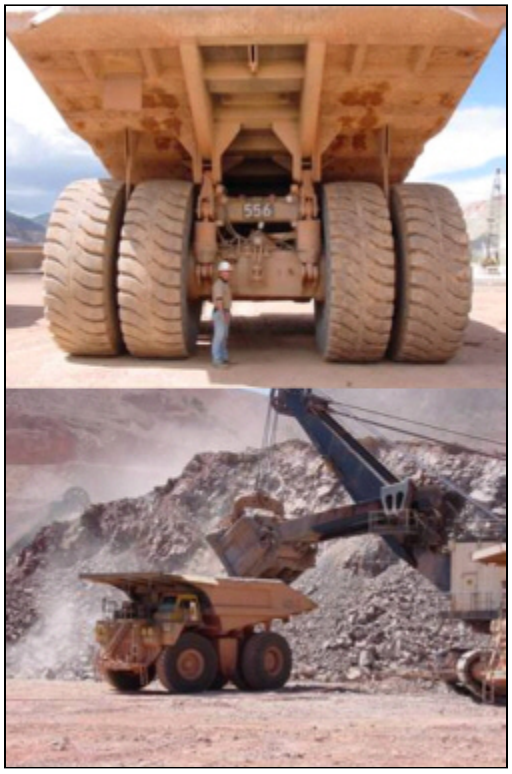
Ongoing Research Project related to Traumatic Injuries

Safety Enhancements for Off-Road Haulage Trucks

PURPOSE: (1) Develop and test interventions that will decrease accidents involving off-highway dump trucks in surface mining operations and (2) disseminate this information to the mining industry, standard-developing organizations, and MSHA to aid in the implementation of effective interventions.

RESEARCH SUMMARY: An average of 675 accidents and 21 fatalities involving powered haulage equipment occurs each year in metal/nonmetal and coal surface mining operations. Three major problems areas are being addressed by this project:

Accidents attributed to the lack of visibility near large haulage equipment. These accidents fall into two main categories: collisions between mining equipment and smaller vehicles, workers on foot, structures, or other equipment; and driving or backing over the edge of an embankment, stock pile, dump point, or other change in terrain. In surface coal and metal/nonmetal mines and quarries, 24 fatalities occurred between 1999 and 2003 that fell into these accident classifications, accounting for 12% of all surface mine fatalities. Dump trucks were involved in 58% of these accidents. To address this problem, researchers are studying available sensor and camera technology to assess which systems are effective in preventing collisions and can handle the conditions of surface mining. To date, a combination of an off-the-shelf radar system and a camera has been thoroughly tested at a surface mine. Preliminary tests have also been conducted on innovative systems developed in cooperation with outside organizations, including a GPS-based system and a stereovision system.



The scale of large mining equipment can be a major factor in accidents. The truck in these pictures is 42 feet long.

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
surface mine safety, blind spots, maintenance, mechanic, slips, falls, powered haulage

Accidents that occur during truck maintenance and tire changing. Mine personnel responsible for equipment maintenance are subject to frequent and heavy lifting, exposure to hazardous substances (oil, gas, hydraulic fluid, antifreeze, welding fumes etc.), working in cramped or awkward spaces, high-pressure hoses and vessels, and a variety of other hazards. Injuries and

fatalities have occurred as a result of exploding vessels, falls from equipment, hand tool use, and falling materials, all of which were directly related to equipment maintenance activities. A thorough examination of fatality and injury data associated with powered haulage maintenance and repair will be conducted to prioritize safety training areas. Potential interventions and overviews of current best practices will also be studied.

Injuries that occur during stepping down from or getting onto equipment. Another issue being addressed is the topic of slips and falls, in particular, accidents associated with accessing large mobile equipment. An average of over 300 accidents per year is reported to MSHA that fall in the mount/dismount category. Improved methods and systems for equipment access are being tested on dump trucks and dozers in cooperation with mining companies and equipment manufacturers.

Ongoing Research Project related to Traumatic Injuries

Safety Solutions to Prevent Mining Materials-Handling Accidents

PURPOSE: Prevent fatalities and injuries associated with materials handling in underground metal and nonmetal mines and in Western surface mining operations.

Loading roof bolt supplies from supply trailer to scoop

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
materials-handling, mechanization, manual tasks, safety solutions, mine safety

RESEARCH SUMMARY: Handling materials by lifting, pulling, pushing, and shoveling (MSHA classification code 09) has been the leading cause of accidents in the U.S. mining industry for every year between 1994 and 2003. The incident rate over this time was slightly more than 2 accidents per 100 employees, not including contractors. During this 10-year period, 58,491 reportable accidents resulted in over 1,000,000 actual days lost from work. In 2003, materials handling was the leading class of reportable mining accidents in every state except Delaware. In the West, stone mines led the way in materials-handling accidents with 3,298 accidents from 1999 through 2003, followed by metal mines (2,537 accidents) and sand-and-gravel operations (1,488 accidents). In every year between 1994 and 2003 except one, the activity of loading and unloading supplies or materials (MSHA activity code 028) caused more accidents in Western mines than any other activity. Many of these accidents were due to manually lifting, pulling, and/or carrying loads that turned out to be too heavy.

Because work tasks in the mining industry are so diverse, the intent of this research was never to conduct detailed ergonomic investigations, but to recommend specific tasks for detailed ergonomic analysis in other PRL or SRL projects; find the contributing factors in materials-handling injuries; develop interventions; and assure delivery to and implementation by industry of useful products. This work is to be accomplished by developing partnerships and conducting investigations in Western stone, sand and gravel, and metal/nonmetal mines; developing training and physical fitness programs designed to prevent materials-handling injuries; conducting national and international searches for proven systems, techniques, and devices that have reduced or replaced manual tasks; and assessing the effectiveness of injury reduction efforts.

In the last 3 years, SRL´s materials-handling research has been specifically directed to investigating two of the top three tasks that cause the most injuries in underground coal mines - loading and unloading supplies and materials and moving power cables. Two mechanical aids have been developed for loading/unloading tasks: the mobile manipulator system and the

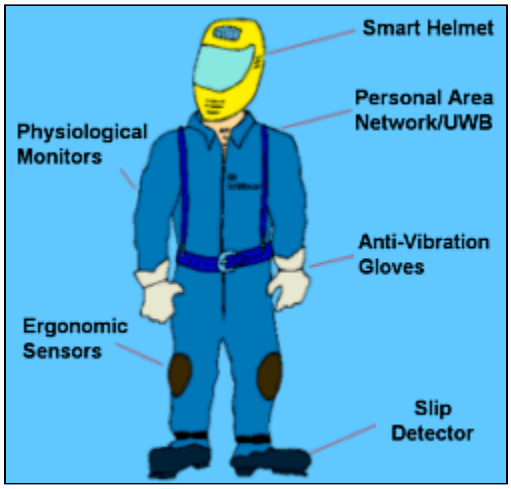
in-mine hoist. A third study involves seeking methods to automate cable handling. We have also developed an innovative in-mine training aid on safe ways to perform certain materials-handling tasks in underground coal mines and developed the concept of sharing safety solutions. Two safety solutions have been placed on the NIOSH mining Web site.

Ongoing Research Project related to Traumatic Injuries

Smart Wearables for Hazardous Work Environments

PURPOSE: This project will investigate the feasibility of wearable technologies to reliably collect and display information that will provide an improved awareness to the worker of existing and impending dangers.

RESEARCH SUMMARY: Miners are constantly exposed to a dynamic and unpredictable hazardous environment. For instance, slipping and tripping hazards are created by mine conditions such as water, mud, uneven floors, and mine-floor obstacles; moving machinery in the confined mine environment creates pinning and striking hazards. We infer from Mine Safety and Health Administration (MSHA) data (1999 to 2003) that the most severe underground mining nonfatal lost-time injuries are for the categories of slips/falls and powered haulage because these injuries resulted in the most lost workdays; a median of 29 lost days for each category. Miners must constantly be able to monitor this hazardous environment in real-time so they can be aware of impending and existing hazards; however, current access to this crucial data is limited. The research scope is for underground coal mining face workers, it is expected this research will readily be applicable to other mining methods and commodities.



Wearable technologies could alert miners of existing or impending hazards

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
mining, protective equipment, hazards, sensors

The specific aims of the research are: 1) identification of hazards for which smart wearable technologies and equipment are appropriate; 2) identification of the uses and limitations of smart wearable technologies with respect to miners in the mine environment; 3) the determination of barriers to effective use of smart wearable technologies. Multiple tasks are defined to realize the specific aims. The first task is to study the mine environment and analyze MSHA accident data in order to determine the crucial environmental parameters needed by mine workers to identify hazards. The second task is to conduct a literature review on appropriate sensor, monitoring, and display devices that will enable the collection, processing, and displaying of crucial hazard information to miners. The third task is to examine and evaluate wearable technologies, as identified by task 2, in terms of wearabilty. The parameters for wearablility include placement, shape, human movement requirements, size diversity, attachment methods, weight, and accessibility. The final task concerns the dissemination of findings through various publications.

The research findings will address the feasibilities and limitations of wearable technology for making miners aware of impending and existing mine hazards. The findings will identify specific mine hazards that could be identified, in real-time, by using wearable technology. The results will be used to determine if additional research is warranted.

Ongoing Research Project related to Traumatic Injuries

Surface Blasting Safety and Health

PURPOSE: Protect miners from hazards associated with blasting at surface operations involving coal, metal, and nonmetal mining.

RESEARCH SUMMARY: This project represents an extension and expansion of research that was formerly investigated by two projects: "Investigation of Flyrock Injuries and Fatalities" and "Toxic Fumes from Blasting."

In recent years, the use of explosives near housing developments has increased. To prevent flyrock that will damage homes or nearby businesses, the blaster ensures that the blast is well confined, i.e., the ground barely moves as it is blasted. However, this provides no way to release the blasting fumes. Thus, the fumes stay in the ground and may travel underground to nearby homes and other confined spaces. The composition of these fumes typically includes carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), and ammonia (NH_3). Since 1988, there have been at least thirteen documented incidents of toxic fumes migration into homes and other confined spaces resulting in several hospitalizations and one fatality. Research is being conducted on the migration of CO and other toxic fumes from blast sites to provide blasters with guidelines for protecting workers and neighbors from fumes poisoning.

Following the detonation of a blast at a field site in Latrobe, PA, a PRL researcher samples for toxic gases in a nearby monitoring borehole

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
blasting, explosives, flyrock, mining

An ongoing hazard in blasting, flyrock and the lack of blast area security, account for the majority of blasting-related injuries and fatalities in surface mining. During FY2001, flyrock and blast area security issues in the mining industry were reviewed and reported. This review of flyrock and blast area security issues is being extended to the construction industry. A training video detailing the hazards due to flyrock and the lack of blast area security will be prepared in cooperation with industry.

Partners/collaborators in the project are the Mine Safety and Health Administration, Institute of Makers of Explosives (IME), and United Mine Workers of America (UMWA).

Ongoing Research Project related to Traumatic Injuries

Virtual Reality for Mine Safety Training

PURPOSE: Create training modules for the Virtual Reality Mine Safety Training (VRMST) software developed at SRL for evaluation in training programs at operating mines.

RESEARCH SUMMARY: Accident report narratives often cite inadequate or insufficient training as a root cause for many fatalities and serious injuries in the mining industry. The research question becomes, Can virtual reality (VR) software be shown to be an effective training medium and can it be successfully incorporated into the training program at operating mines? Through experiencing virtual reality training, can mine workers be better prepared to identify and manage hazardous operating conditions?

SRL researchers test a fire evacuation training module using the VRMST software on a multi-user mobile pc network

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STRATEGIC GOAL:
Traumatic injuries

KEYWORDS:
virtual reality, computer-based training, mine safety training, game

Numerous training topics are adaptable to the virtual reality training medium. First, project staff will identify appropriate topics for adaptation to VR training modules. Existing training materials will be used as the basis for the virtual experience to provide a proven basis, and allow evaluation of the effectiveness of the VR modules. These training scenarios will be recreated in the VRMST software using mine maps, equipment models, audio scripts, and digital imagery. The modules will undergo rigorous in-house testing prior to release for evaluation.

The software will increase worker safety by graphically illustrating the results of bad choices and incorrect decisions without actually exposing the trainee to danger. The simulations developed by this project are meant to enhance current training techniques by providing simulated hands-on, accurate, interactive training environments for workers. The inherent flexibility of this type of simulator will allow easy and rapid updating and modification of the training modules, based on stakeholder feedback. The development of the VR scenarios will rely on computer graphics technology developed for the personal computer game industry. This technology is affordable, widely distributed, and provides rich, complex, and flexible virtual environments that can be tailored to meet the training needs of the mining industry as well as the construction and agricultural industries. The software could ultimately be distributed via the Internet to allow end-users to receive frequent software updates, share user-created scenarios, and participate in on-line, multi-user training.

Ongoing Research Project related to Mine Disasters

CCER Standard

PURPOSE: Develop certification standards for the approval of self-contained, closed-circuit breathing apparatus used for escape from atmospheres considered to be immediately dangerous to life and health.

RESEARCH SUMMARY: Closed-Circuit Escape Respirators (CCERs) or Self-Contained Self-Rescuers (SCSRs which is a term used by the mining industry) are used by approximately 50,000 underground mine employees. The overall objective is that no miner should be forced to rely upon an SCSR that might be unsafe for a mine escape. Escape means taking a miner on foot and under oxygen from the deepest point in the mine to a point of safety. A review of the past history of problems encountered with SCSRs during CPIP Investigations reveals that, approximately 40% of the problems involved reliability issues.

Inspection of Self-Contained-Self-Rescuers at an underground coal mine

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
Self-Contained Self-Rescuers, SCSRs, respirators, underground mining

Storage of CCERs in harsh environmental conditions, such as heat, cold, and humidity, and the daily wearing of the respirators on and around vibration-generating equipment and tools and during physical work, can result in damage that degrades the respirators´ performance, despite their protective cases. NIOSH field evaluations of certified CCERs conducted systematically and in response to the concerns of users have identified damaged respirators that failed to meet the performance criteria under which they were certified. In some instances, the designs of these respirators, however, did not allow the wearer or employer to evaluate the condition of a particular respirator prior to its use in either an evacuation drill or an actual emergency. Respirator manufacturers have since added design improvements to allow users to check the potential for certain types of damage, but current certification requirements do not specifically govern the inclusion of such checks. Furthermore, current performance testing requirements for CCERs, some of which were established in 1919, rely on a non-uniform testing regime in which differences between human subjects involved in the testing can produce varying test results. The improvements being proposed would establish a consistent testing regimen for evaluating the life support capability of CCERs.

Finally, the current certification requirements are the cause of a risk communication and risk management problem. The requirements compel NIOSH to certify these respirators as providing protection for a specific duration applicable to the particular class of respirator. These durations may be misleading to employers and users, however, because the duration for which one of these respirators will provide effective protection in the workplace, versus in laboratory testing, will depend on the body weight and physical condition of the user and on the amount of exertion required by the escape.

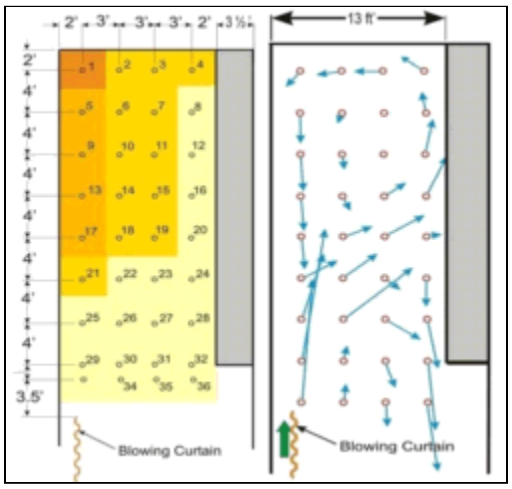
To address the reliability issues involved with the current units, the new standards will incorporate: ruggedness and hazard testing; breathing and metabolic simulator (BMS) testing for capacity, performance, and wearability testing requirements; early detection audits by non-destructive and post certification testing; and voluntary registrations.

Ongoing Research Project related to Mine Disasters

Coal Mine Face Methane Control and Monitoring

PURPOSE: Reduce or eliminate hazardous frictional ignitions at coal mine working faces through improved face ventilation and enhanced positioning of machine-mounted methane monitors.

RESEARCH SUMMARY: Large volumes of methane can be released at the mining face during coal extraction. When the lower explosive limit (LEL) is exceeded, this methane-air mixture is capable of being ignited if it contacts hot cutting bits on a mining machine. These frictional ignitions can injure, sometimes fatally, those working in the vicinity. To prevent frictional ignitions, an adequate quantity of fresh air must be provided to the mining face to dilute methane below the LEL. In addition, continuous methane monitoring is essential to assure that the LEL has not been exceeded.



Face-release methane levels and ventilating air flow data

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
mining, methanometer, ventilation, underground technology, control technology, simulation

To determine the effectiveness that different ventilation techniques have on diluting and carrying-off methane emissions at the mining face, researchers are conducting ventilation studies in a full-scale coal mine face gallery. Three-axis ultrasonic anemometers are placed at predetermined locations to measure airflow speed and direction. Results have shown that variables, such as air quantity and entry width, can affect airflow patterns and methane concentrations near the face. Presently, research is being performed to more accurately define the relationship of face air velocities and methane levels.

Studies are also evaluating the relationship between air velocities and the accurate detection of methane at typical machine-mounted methane sensor locations. Preliminary results have shown that these methane-sampling locations are not ideal. Research will determine the practicality of moving the machine-mounted continuous monitor to different locations on the machine. This work will determine which locations provide; 1) a more accurate indication of true methane concentrations, and 2) the fastest response-times to changing face methane levels. Ideally, the results will optimize the location of the monitor, minimizing the potential for methane ignitions at the face.

Research products will provide guidelines for improving face airflow and controlling face methane levels with the goal being to reduce or eliminate methane ignitions at the working face. To enhance face worker safety, it is imperative that advancements in face ventilation and methanometer placement be reviewed, accepted, and incorporated into the mining industry´s face ventilation plans. To promote these findings a research-derived transfer of technology will be provided to MSHA, private industry, labor organizations, and miners. These outputs will be in the form of written publications and both formal and informal presentations.

Ongoing Research Project related to Mine Disasters

Design Guidelines for Mine Ventilation Stoppings

PURPOSE: To develop engineering guidelines for underground mine ventilation stoppings that will help to ensure the compatibility of these structures with in-service load conditions to prevent premature failures that can lead to disastrous conditions. A secondary objective is to develop light-weight materials into satisfactory construction designs to reduce the potential of material handling injuries.

Full-scale verification testing in the NIOSH Experimental Coal mine of the transverse loading capacity of a mine ventilation stopping

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
coal mining, code of federal regulations, mine ventilation stoppings, mine seals, ASTM E-72

RESEARCH SUMMARY: Nearly all commodities of bedded deposit formations mined by underground methods use some form of permanent stoppings to control ventilation. Hundreds of thousands of these critical structures are constructed each year in underground mines. Failure of these structures can lead to disastrous fires and mine explosions. The current focus of this work is to develop engineering design guidelines for stopping construction in underground coal mines. The current Code of Federal Regulations (CFR) protocols do not fully address the in-service load conditions for these ventilation control structures and allow a wide range of stopping designs with varying transverse load capabilities to be installed in any mine environment. This can lead to dangerous conditions where the ventilation control capability can be less than expected and inadequate in certain conditions. New protocols that will provide a parametric study of the variables that impact the loading and stability of these structures need to be developed and discussed with the Mine Safety and Health Administration´s Technical Support. This will lead to more relevant design guidelines for stoppings that will ultimately provide for safer mining conditions by constructing stoppings suitable to control normal ventilation pressures and certain levels of over pressurization when the need arises. The preliminary research efforts have shown that arching is a more valid representation of the loading behavior that occurs in the mine compared to the free-standing analysis currently considered in the CFR. It has been demonstrated that arching can increase the transverse load capacity of stoppings by more than an order of magnitude. A new protocol to evaluate the transverse loading capability of stoppings through biaxial half-wall testing of dry-stacked block stopping constructions in the Mine Roof Simulator load frame has been developed and verified through full-scale testing in both the NIOSH Experimental Coal Mine and Lake Lynn Laboratory. Preliminary design equations have been developed for conventional dry-stacked block stoppings from this work and complete design guidelines prepared at the conclusion of the project.

Ongoing Research Project related to Mine Disasters

Fire Hazard Reduction in the Metal and Nonmetal Mining Industry

PURPOSE: The purpose of this research project is to reduce the incidence of fires and injuries due to fire through a comprehensive program of education, training, and basic and applied research that addresses the unique fire safety problems within the M/NM mining industry.

RESEARCH SUMMARY: The annual number of fires occurring within the M/NM mining industry is comparable to the number occurring within the coal mining industry. This project is divided into four major tasks that address the fire safety problems within the M/NM mining industry. PRL possesses unique facilities and expertise to address these problems and to conduct the research necessary for their solution. Research on fires involving large vehicles/equipment will be used to develop improved fire control and prevention techniques and improved fire extinguishment and suppression systems, including improved systems for protection of equipment operators and novel systems for prevention of re-ignition of flammable fuel vapors from ruptured hydraulic or fuel lines.

Experiment to evaluate the effectiveness of a cab detection/suppression system

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STRATEGIC GOAL:
Mine disasters

Research on the fire resistance and flammability of combustible materials will seek to identify those combustibles most in need of more stringent fire resistance ratings and to develop and recommend tests that satisfy these needs, such as noise abatement materials, hydraulic fluids, and conveyor belting.

Research on early-warning fire detection will be used not only to develop and improve upon current fire detection technology, such as intelligent smoke sensors, but also to develop strategies and guidelines for the deployment of fire sensors and systems for a diverse range of applications.

The development of fire safety training and educational materials, including hands-on training and workshops, will be developed for the M/NM industry in order to increase worker awareness to the hazards of fire and the appropriate techniques for prevention and response.

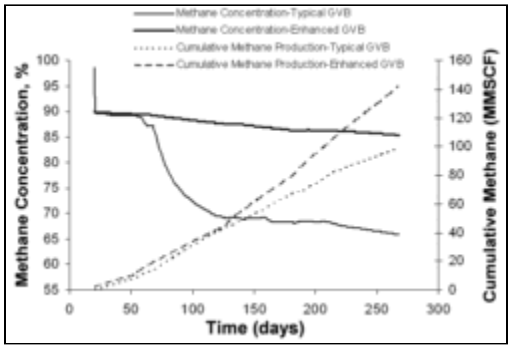
Outputs of the project will include publications and presentations in peer-reviewed journals and at peer-reviewed conferences and fire safety training workshops that address the needs of the M/NM mining industry. The target outcome of the project is to reduce the rate of occurrence of fires and injuries due to fire by 25% in the first two years following project completion with further reductions in subsequent years. Such reductions result in significant benefits, not only in terms of reduced injuries and fatalities but also in terms of improved operating efficiency and cost of mining.

Ongoing Research Project related to Mine Disasters

Investigation of Methane Control Issues in Underground Mines

PURPOSE: To investigate existing and evolving methane control issues in coal mines and develop control strategies to reduce the risk of explosions in the underground workplace.

RESEARCH SUMMARY: The inability to quantitatively forecast and control methane accumulations and emissions represents a significant risk for explosions in the underground workplace, and may have contributed to 106 U.S. coal miner deaths in 17 explosions since 1980. Recent explosions have occurred at mines in West Virginia (3 fatalities and 3 injuries, 2003), Alabama (13 fatalities, 3 injuries, 2001), and Utah (2 fatalities and 8 injuries, 2000). The inability to control methane emissions can be the product of: (1) inadequacies in the ventilation and/or methane control system configurations; (2) the inability to forecast the methane emission consequences of changes in mine design, or geologic conditions; or (3) uncertainty as to how to remediate methane emission problems. Frictional ignitions are an additional, poorly understood explosion hazard, and may be the source of a 1998 mine fire in Utah which eventually resulted in the abandonment of the mine.



Comparison of methane concentrations and cumulative methane drainage volumes using existing well completions vs. optimally completed and produced gob gas venthole configurations on a simulated 1,450-ft wide longwall panel

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
explosions, underground mining, ventilation

This research effort is designed to investigate and quantify the geotechnical factors and mine design practices influencing methane emissions and the occurrence of frictional ignitions. It is expected that the primary initial outcome will be a set of methane control best practices. A comprehensive research methane emission and gas flow predictive model is also being developed. A version of the research model will be integrated with ventilation models commonly used in the mining industry so that methane control strategies can be evaluated and included in the ventilation planning process. Rock samples are being collected from historically friction ignition prone mines for geotechnical characterization to develop a qualitative incendivity index and will be used as input to ignition control technology techniques.

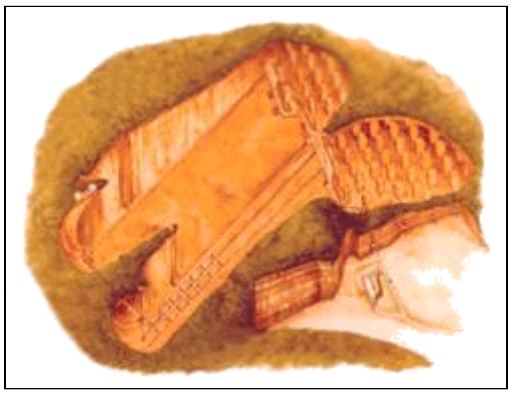
The adaptation of commercially available reservoir modeling software has successfully simulated gas flows in a longwall mining scenario. The simulations have shown that for the Pittsburgh Coalbed, the industry trend towards wider panels will probably result in increased methane emissions. Various gob gas venthole configurations have also been simulated to evaluate potential optimized methane drainage strategies for longwall panels of increased panel widths. Two unique empirical methods for predicting longwall face emissions for increased

longwall face lengths have been presented to industry. An analysis of historical frictional ignition data has shown that the majority of these events occurred in the Mary Lee/Blue Creek and the Pocahontas No. 3 coalbeds. Most frictional events occurred on continuous miner sections associated with operating longwalls.

Ongoing Research Project related to Mine Disasters

Lake Lynn Laboratory

PURPOSE: Provide a modern, full-scale realistic laboratory for underground and surface research that significantly contributes to the enhancement of workplace safety and health for miners and other workers.



Experimental mine at Lake Lynn Laboratory

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
Lake Lynn Laboratory, health and safety, explosions, fires, explosives

RESEARCH SUMMARY: Lake Lynn Laboratory near Fairchance, PA, provides an isolated surface facility and a full-scale underground mine to conduct large-scale research in mine disaster prevention and response, as well as numerous other research areas of national interest requiring the study of large-scale surface and underground safety and health problems. The ability of Lake Lynn to simulate virtually any underground coal mine geometry provides a practical, realistic research laboratory for mining research under various controlled conditions of ventilation, humidity, pressure, and temperature. To facilitate the underground research, electrical power, compressed air, water, communications, video lines, natural gas lines, and a unique high-speed data-gathering instrumentation system have been incorporated into the design at the site. The surface facilities provide an isolated environment in which large-scale research and testing can be conducted in a realistic, yet environmentally controlled manner.

On-going research at Lake Lynn includes the development and evaluation of fire suppression systems and early warning technologies, development and evaluation of mine seals and other ventilation structures, evaluation of prototype mining equipment and sensors, noise control studies, ventilation studies, roof support technologies, evaluation of explosive incendivity and toxic gases, determination of explosion limits for combustible dusts and ignitability of mists and vapors, mine rescue team training evaluations in smoke-filled entries, and respirable dust deposition and diesel particulate studies. The information generated as a result of the research conducted at Lake Lynn is vital to the mining industry in the development of improved technology and practices to protect mining personnel from the many hazards associated with their jobs. Although the primary mission of Lake Lynn is in support of mine safety and health programs, the unique characteristics of the facility make it attractive for research in support of other industrial problems. Cooperative research within these areas is often conducted on a resource availability, cost-reimbursement basis. This project supports and coordinates all of the Lake Lynn research efforts; enhances the research capabilities of Lake Lynn; and maintains safety, health, and environmental controls at Lake Lynn.

Ongoing Research Project related to Mine Disasters

Long Term Field Evaluation (LTFE)

PURPOSE: To monitor the reliability of Self-Contained Self-Rescuers (SCSRs) deployed in US underground coal mines.

RESEARCH SUMMARY: After an underground mine fire or explosion, the mine atmosphere may become oxygen deficient or filled with smoke and toxic gases. Respiratory protection is necessary for successful escape from the mine. Only closed-circuit breathing apparatus known as SCSRs can provide the life support capacity necessary for emergency escape.

SCSRs have been deployed in US underground coal mines since 1981, and the LTFE began shortly after, as a joint USBM/MSHA project to monitor their reliability and assure their proper functioning in the event of emergency use. Today, the LTFE collects and tests nearly 200 SCSRs per year.

As a result of LTFE investigations, many problems with SCSRs have been discovered, ranging from quality control failure, aging, mine environment impact, as well as poor inspection procedures. As a result, about 55,000 SCSRs have been recalled or decertified, and recommended changes in inspection procedures or donning instructions have affected about 70,000 SCSRs. Because of lessons learned from the LTFE design changes have been and are continuing to be made to improve the performance and reliability of SCSRs.

Escape Training using Self-Contained-Self-Rescuers in an underground coal mine

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
Self-Contained Self-Rescuers, SCSRs, Long Term Field Evaluation, LTFE, mine escape

Ongoing Research Project related to Mine Disasters

Mine Rescue and Response

PURPOSE: To improve the state of readiness for emergency responders and increase the chances of survival for personnel escaping from underground emergencies.

RESEARCH SUMMARY: Our Nation´s miners often rely on emergency responders to save their lives in the event of an underground emergency, such as a fire or explosion. Approximately 650 underground coal mines and 240 underground metal/nonmetal mines operate in the United States and employ a workforce of 44,000 miners. There are currently 260 mine rescue teams with about 1,700 members. These dedicated groups of miners often put their lives in jeopardy to save others. It is important that team members are provided with the latest personal protective equipment, be well trained, physically and mentally fit, and fully understand the hazards that may await them during rescue operations. Miners are often the first responders to an emergency, such as a fire, and must decide if they should fight the fire or evacuate the mine.

Mine Rescue Team training

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
emergency responders, mining, training, fire

This project enhances the safety, preparedness and effectiveness of mine emergency responders, including evacuating miners, fire brigades, and mine rescue teams, by developing and conducting realistic training simulations and improving technology for rescue, exploration, recovery, fire fighting and evacuation. The mine fire preparedness and response capabilities of mining operations are assessed by the development of comprehensive checklists. Methodologies and training interventions to enhance the accurate communication of information and decision making during the initial phase of mine emergencies are also being developed, evaluated and implemented.

Realistic training simulations for mine emergency responders have and continue to be developed, conducted and evaluated in collaboration with State mining agencies and mining companies. These simulations are held at the NIOSH Lake Lynn Laboratory and at operating mines and include training for exploration, rescue and recovery operations, combating liquid fuel and conveyor belt fires, and the evacuation of miners in smoke filled passageways. Over 135 mine rescue simulations have been conducted and over 2,500 miners participated in the various training exercises. The participants gain a better awareness of the hazards associated with mine emergencies, increase their response skills and confidence levels, and enhance the

operational effectiveness of rescue teams and command centers. Improved technologies for mine emergency responders have also been identified and evaluated. These include chemical light shapes, lighted vests, strobe lights, laser pointers, lifelines, a patented lighted team link line, wheeled stretchers, thermal imaging cameras, and state-of-the-art communication systems.

Ongoing Research Project related to Mine Disasters

Prevention and Mitigation of Gas/Dust Explosions

PURPOSE: To reduce hazards in mining through basic and applied research on the prevention and mitigation of gas and dust explosions and the education of mining personnel on explosion hazard recognition and prevention.

RESEARCH SUMMARY: While much progress has been made in preventing disasters in mines, explosions still occur, often producing multiple fatalities. In an explosion, all underground miners are at risk. There were serious underground coal mine explosions in July 2000 at a Utah mine (2 fatalities and 8 injuries), in September 2001 at an Alabama mine (13 fatalities and 3 injuries), and in January 2003 at a West Virginia mine (3 fatalities and 3 injuries). Explosions are caused by accumulations of flammable gas and/or combustible dust mixed with air in the presence of an ignition source. Research on gas and dust explosions is needed as a basis for the development of techniques and strategies for explosion prevention, suppression, and mitigation.

Collection of floor dust sample after explosion in the Lake Lynn Experimental Mine

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
explosions, mining, ventilation

This project studies explosion propagation and explosion combustion mechanisms through full-scale tests at the Lake Lynn Experimental Mine (LLEM) and through laboratory tests in a 20 liter chamber. The LLEM research includes the effects of turbulence and confinement on the initial stages of a gas explosion, the requirements for transition from a small gas explosion to a full-scale propagating dust explosion, and flame propagation in large volumes of nonuniformly mixed methane. In conjunction with these LLEM tests, there is a task to improve the supporting documentation/research used by the Mine Safety and Health Administration (MSHA) in investigating explosion disasters. In a collaborative task with MSHA, an in-situ meter has been developed to quickly determine the explosibility and/or the incombustible content of coal and rock dust mixtures in coal mines, thereby improving sample analysis and rock dusting practices.

The results of this research so far have been communicated to stakeholders in four briefing reports to MSHA, two conference papers, a book chapter, and a peer-reviewed journal paper. Achievements include the development of improved forensic procedures for use by MSHA in investigating mine explosion accidents and the development of improved laboratory test methods as consensus standards for the determination of explosibility characteristics. Additional recommendations on the best practices to prevent and/or mitigate explosion hazards are

expected. The outcome of this research effort will be a reduction in the risk for gas/dust explosions in the underground workplace through an increased understanding of the causative factors for these events, the development of improved control technologies, and educating the workforce to recognize and prevent explosions.

Ongoing Research Project related to Mine Disasters

Prevention and Mitigation of Mine Inundations

PURPOSE: Minimize hazards associated with water/slurry impoundments in an underground coal mine by developing a set of guidelines that discuss physical, geological, structural, and safety issues for consideration when designing a safe and efficient bulkhead system.

Hydrostatic testing of mine seal at Lake Lynn Laboratory

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
ventilation, ground control, underground mining

RESEARCH SUMMARY: While much progress has been made in preventing disasters in mines, inundations still occur and have the real potential of producing multiple fatalities. Many mining operations rely on bulkheads or ventilation seals to provide a barrier between impounded water and active mine works. Since 1995, there have been over 100 inundation accidents reported by MSHA where mining has cut into underground bodies of water. These inundations serve to illustrate the potential risk to miners while working near such large impoundments.

NIOSH personnel met with personnel at (4) Mine Safety and Health Administration (MSHA) District Offices, the West Virginia Office of Miners´ Health Safety and Training, and Pennsylvania´s Department of Environmental Protection to document locations of bulkhead installations. While in the field, researchers toured mining operations in WV, MD, KY, and AL to gain first hand knowledge of operational issues related to bulkheads. Deep mine inspectors, permit reviewers, mining engineers, design engineers, and bulkhead construction firms were also contacted to better understand the permitting process. To date, in-depth reviews of 28 permit applications have been completed. The data from permit reviews along information gathered during site visits has been entered into a comprehensive Bulkhead Installation data base containing information on existing bulkhead designs and performance case histories. The data base is helping researchers identify trends in design, intended purpose, pressure rating, emergency relief options, and emergency response plans. Full scale hydrostatic testing of mine ventilation seals that can be exposed to hydraulic pressures was conducted at the Lake Lynn Laboratory to provide data on leakage rates and failure mechanisms. Uniaxial compressive testing was performed on core samples taken from the test ventilation seal. The field information and full scale testing data will be culminated into a comprehensive design manual that considers the strength of the bulkhead structures and addresses the parameters that affect the system design such as overburden depth, barrier pillar strength, proximity to adjacent mine works and surface impoundments, method of reducing water elevation, evacuation routes, and emergency planning.

The expected outcomes are: (1) better evaluation measures for bulkhead designs; (2) improved designs that interface with mine strata to better protect miners from a massive in-rush of water or mine waste; (3) identify key factors that have resulted in successful bulkhead designs and rock interfaces over the last 15 years.

Ongoing Research Project related to Mine Disasters

Reducing Fire Hazards in U.S. Coal Mines

PURPOSE: To reduce the occurrence of spontaneous combustion in underground coal mines, particularly in mines that have appreciable levels of methane, and to reduce the fire hazards in coal mines associated with flame cutting and welding operations.

Inert gas injection into borehole to control mine fire

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
fires, spontaneous combustion, flame cutting and welding

RESEARCH SUMMARY: Most spontaneous combustion fires occur in worked-out areas that are not accessible and require remote detection and extinguishing efforts. This hazard is a particular concern in mines with both a high spontaneous combustion risk and high levels of methane, since most ventilation schemes utilized to remove methane from the mine exacerbate the spontaneous combustion hazards. An understanding of how various ventilation practices affect spontaneous combustion is needed. Research is required to develop ventilation methods that both remove the methane and minimize the risk of spontaneous heating. Case studies are being conducted to determine the causative factors and the role of ventilation in the heating events. The information from these studies, along with experiments to characterize gob ventilation, is being incorporated into computational fluid dynamic models to evaluate ventilation schemes to dilute methane and minimize the self-heating risk in spontaneous combustion-prone mines. In addition, models are being developed to evaluate various sealing and inert gas techniques to combat self-heating in gob areas. This research will result in improved ventilation practices and technologies to reduce the number of fires and the risk of spontaneous combustion fires in mines with both a high spontaneous combustion risk and high levels of methane.

Analyses of fires in the coal mining industry for the period 1990 - 2002 indicated that 110 of the 560 reported fires were the result of either flame cutting or welding operations. These fires resulted in 70 injuries and 2 fatalities. In a 2003 mine accident, a shaft explosion in West Virginia due to flame cutting caused 3 fatalities and 3 injuries. The root causes of flame cutting and welding fires are being determined and improved methodologies and technologies are being developed and evaluated to prevent these types of fires. Accident investigations are being scrutinized, workers interviewed, and flame cutting and welding operations at operating mines are being observed. Procedures, regulations, and other standards and existing guidelines are being analyzed to determine the root causes of cutting and welding fires in the coal sector and

identify possible interventions. Training procedures and preventive equipment are being developed and evaluated. This research will result in new guidelines for flame cutting and welding in coal mining operations and a reduction in the number of fires and injuries due to flame cutting and welding operations.

Ongoing Research Project related to Mine Disasters

Remote Methods for Addressing Coal Mine Fires

PURPOSE: To provide, through technology testing and improvement, more reliable remote mine fire suppression technology and to directly transfer these improvements to the coal mining industry.

NIOSH researcher observes the movement of fire-fighting foam at the Lake Lynn Experimental Mine

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
underground mining, explosions, fires, remote seals, compressed-gas foam

RESEARCH SUMMARY: Mine fires constitute one of the greatest threats to the health and safety of those working underground. Since 2000, a total of 17 mine fires have occurred in the United States. On average, three mine fires occur each year and over the period from 2000 to the present, a maximum of five mine fires have occurred in a one-year period. These statistics suggest that mine fires are occurring with alarming regularity, yet there has been no improvement in the technology for fighting a mine fire. Although not all mine fires cause fatalities, they have the potential for catastrophic results. Improvements in remote fire fighting technology are needed to reduce miner exposure and possibly save the lives of those that may become trapped.

Mine seals are often constructed when access to the fire zone is impossible. A correctly constructed mine seal is designed to close-off the mine opening to prevent the inflow of oxygen and isolate a fire zone. Underground observations suggest that the currently available technology used to construct remote mine seals often fails to fully close the mine opening. Thus it is impossible render the mine atmosphere inert because air can move freely move into the fire zone. Remote fire-fighting methods are usually restricted to sealing the mine and inerting the mine with gas. This results in dangerous atmospheric conditions that are extremely hazardous to mine rescue and recovery personnel. Gas-enriched foam systems have recently been used to remotely fight underground fires, but they have not been fully evaluated in a controlled mine environment to determine the best chemical formulation and method for application. It is believed that gas-enhanced foam offers promise given a sufficient underground life and the capability to efficiently move and migrate through a mine opening to the fire.

Remote mine seal construction and gas-enhanced foam technology are being tested and evaluated in the Lake Lynn Experimental Mine. At this site, full-scale explosions and deep-seated mine fires can be initiated to test technology under real-life conditions. The goal of this work is to fully integrate the improved technology into the mine fire-fighting arsenal very soon after completion of the work. This will be accomplished through a focused, industry-wide Technology Transfer effort and direct interaction with the state and federal regulatory officials who manage and monitor mine fire suppression efforts.

Ongoing Research Project related to Mine Disasters

SCSR Training Modules

PURPOSE: To enhance SCSR care, maintenance, and inspection protocol so that miners keep SCSRs in good condition and all units that fail inspections are removed from service.

RESEARCH SUMMARY: SCSRs are used by approximately 50,000 underground mine employees. Training in care, maintenance and inspection is paramount to ensure that the device functions properly when donned by a mine worker during an emergency. The modules will be available from the NIOSH and MSHA Internet sites. NIOSH, in joint participation with MSHA, will initiate an intervention strategy for introducing these modules to the mining industry through their Educational Field Specialists. In addition, the agencies are collaborating on the effectiveness that these training modules have on SCSR user readiness.

Proper donning method for SCSRs

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
Self-Contained Self-Rescuers, SCSRs, respirators, underground mining

The intent of the project is to continue the development of specific SCSR care and maintenance training modules for each NIOSH certified SCSR. Each module will have information and training content specific to the type of SCSR. The objective of this intervention is to improve workers' understanding of the care, maintenance, and inspection procedures to ensure that SCSRs are kept in good condition and to remove all units that fail inspection from service. The modules use the previously approved ACSE SR100 Care and Maintenance Training Module as a template to develop SCSR specific training modules representing the three remaining manufacturers' units. The training module components include a 16-minute video, a CBT training exercise, an instructor's guide and a sticker. Each module contains five elements, which include daily inspection, 90-day inspection, donning sequence, use/care/maintenance, and sensory expectations.

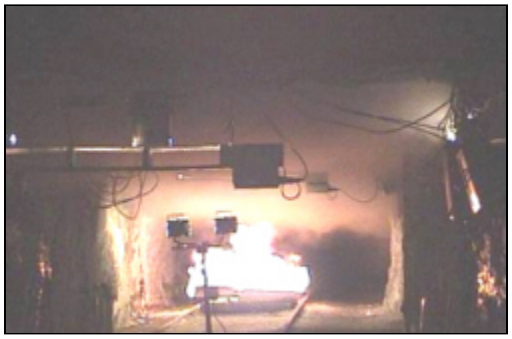
All materials are developed in cooperation with the specific manufacturer to ensure content validity. MSHA is participating in an Interagency Agreement to produce the training modules at their training academy, Beckley West Virginia. Development and distribution of the modules is supported by the United Mine Workers of America (UMWA), Bituminous Coal Operators Association (BCOA), and MSHA.

Ongoing Research Project related to Mine Disasters

Smoke Management and Fire Modeling for Underground Mines

PURPOSE: To develop a real-time mine fire simulator with mine ventilation and smoke control decision making capability based on mine fire sensor data to determine the most effective smoke management methods to provide safe miner egress and safe access for fire-fighters.

RESEARCH SUMMARY: Fires continue to be a major hazard in underground mines. During a mine fire, the operator usually has very limited fire sensor information. This data could be more efficiently applied to emergency smoke management and fire suppression decisions if an interactive mine fire simulator was available. There is no existing strategy to control the movement and dilution of smoke associated with an underground mine fire. Therefore, the primary and only response to a mine fire is egression from the mine or fire region. Without a scientific understanding of fire development and smoke transport, safe and effective smoke management methods cannot be deployed to avert the hazards of toxic smoke and low visibility under emergency mine fire conditions.



Smoke reversal from a small diesel fire

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STRATEGIC GOAL:
Mine disasters

KEYWORDS:
fires, underground mining, ventilation

The mine fire simulator will be developed for applications to miner safety in underground mines. In support of this project outcome, in-mine fire and smoke transport experiments, fire spread modeling with advanced computational fluid dynamic (CFD) programs, optimum sensor site location experiments, fire risk assessment strategies, and smoke leakage experiments will be conducted. The effects of ventilation upon smoke leakage from a fire in a return airway into an intake airway under low air flow conditions will be evaluated experimentally. As an outcome smoke control measures will be developed and evaluated. Thus far, it has been determined experimentally and computationally that the ventilation required to prevent smoke rollback along the roof from a fire in a mine entry can be specified by a mathematical relationship. This function will be incorporated into the mine fire simulator.

As a mine fire emergency preplanning tool, the simulator will provide the development of strategies for smoke control and the development of a smoke control plan based upon anticipated mine fire scenarios. As a real-time emergency tool, the fire simulator will provide the mine operator with real-time data to evaluate and manage ventilation during a mine fire to allow miners safe egress from the mine. In both cases, the simulator will be forward looking with recommendations for diluting the smoke and toxic gases to acceptable levels for safe egress from the mine and for the safe approach of fire fighters.

Ongoing Research Project related to Ground Control

Development and Evaluation of Innovative Roof Support Technologies

PURPOSE: To facilitate the development of new roof support technologies through industry partnerships with various support manufacturers, and to ensure that these new support technologies meet basic safety standards before they are commercialized for use in underground mines.

Prestressing unit used to preload a Can support

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STRATEGIC GOAL:
Ground control

KEYWORDS:
coal mining, roof support, underground mining, emerging technologies

RESEARCH SUMMARY: Ground control is a fundamental aspect of all underground mining. Historically, between 30 and 40 pct of the fatalities in underground mines are caused by the unstable roof rock falling in on the miner, and this percentage has been increasing in recent years. Roof support systems are routinely installed in all mines in an effort to prevent these catastrophic roof falls from occurring. Due to the importance of ground control, roof support manufacturers continually strive to develop new roof support technologies that provide superior ground control at less cost. Our goal is to make sure that new support technologies are properly designed to ensure the safety of mineworkers. Through a cooperative program with the various support manufacturers, each new support technology is rigorously tested in NIOSH's unique Mine Roof Simulator. During the development of a new support system, this testing identifies design deficiencies so that they can be corrected. Once the support system satisfactorily passes this testing protocol, then the performance characteristics and its limitations are determined in order to optimize the safe use of this support in the mine. Nineteen new or modified roof support systems produced by seven different companies were evaluated this past year. These products are then implemented into the NIOSH Support Technology Optimization Program (STOP). This is a design software system that allows anyone to compare the performance of the various products and to match the appropriate support with the conditions in a particular mine to provide the most effective and safe ground control possible. NIOSH also provides technical guidance to the Mine Safety and Health Administration regarding the approval of new support technologies and participates in several technology transfer efforts each year to promote the safety advantages of these improvements in roof support.

Ongoing Research Project related to Ground Control

Fragmentation Methods and Ground Control Safety

PURPOSE: Investigate the complex relationships between fragmentation, rock scaling, ground support, and safety in mines that use drilling and blasting as the primary excavation method.

RESEARCH SUMMARY: Rock falls are one of the most serious causes of fatal injury to underground miners. From 1998 through 2002, the fatal injury rate in underground mines was 56.2 (i.e., the number of fatalities per 100,000 full-time-equivalent workers). Of these, the Mine Safety and Health Administration (MSHA) classified 43.3% as being caused by falls of ground.

Metal and stone mines typically excavate rock using explosives. If too much is used, the rock surrounding the opening can be excessively fractured, and workers can be endangered by loose and falling rock when they enter the workplace. Fractured, weakened, and/or loosened rock must be either scaled or supported. Both of these activities are extremely hazardous.

Split Hopkinson pressure bar test facility

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STRATEGIC GOAL:
Ground control

KEYWORDS:
blasting, fragmentation, overbreak, supports, scaling, rock falls

The research problem addressed by this project was whether advanced fragmentation techniques could be used to minimize the hazards associated with rock falls. These techniques include various controlled blasting methods and new products, such as electronic detonators and string emulsion, that have the potential to reduce excessive fragmentation of surrounding ground and preserve more of the inherent strength of the rock. Such techniques have been applied in many civil engineering projects and have been introduced in some sectors of the mining industry. Although these methods promise better ground control safety, the benefits have rarely been quantified.

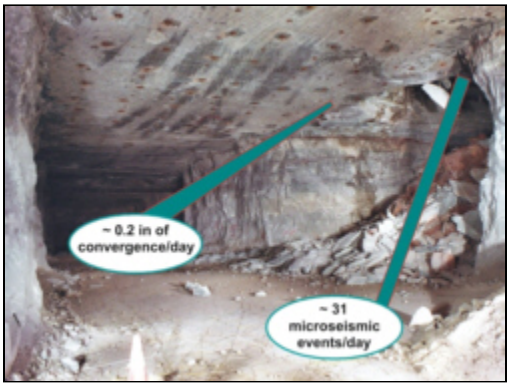
In this project, researchers seek to quantify the interaction of fragmentation, rock scaling, and support methods, allowing them to be optimized as a single system. The first step in this research is to study and classify the dynamic response of rocks. A 60-mm split Hopkinson pressure bar was set up to measure the extent of fracturing in different types of rock. Assessment methods are being developed to evaluate the extent of rock fracturing. A follow-up project that builds upon this work is planned that will use a systems approach to look at not only blasting, but also the drilling, scaling, and support portions of the mining cycle. Future work includes single-hole blast testing, development of an RMR-based blasting model, improved mathematical models, field verification tests, and demonstrations at mine sites. This information will be used to reduce hazards related to rock falls at mining operations.

Ongoing Research Project related to Ground Control

Fundamental Studies of Factors Responsible for Falls of Ground

PURPOSE: This project serves to design, test, and demonstrate the potential of monitoring technologies to warn of roof fall occurrences.

RESEARCH SUMMARY: Reducing the number of ground fall injuries is a central goal of the NIOSH mine safety research program. This research effort is aimed at advancing our basic understanding of the causes of ground falls and using this knowledge, in conjunction with state-of-the-art monitoring technology, to warn of large roof fall occurrences. Central to this project will be the collection of microseismic and roof deflection information from several sophisticated monitoring systems at field sites where roof falls occur. These monitoring data will be compared with actual field observations to determine: the characteristics of the detectable roof falls; the timing sequence between roof falls and measurable microseismic activity; trends in the data to warn of roof falls; and limitations in this technology to anticipate roof falls.



Monitoring rock failures and roof movements to warn of roof falls

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STRATEGIC GOAL:
Ground control

KEYWORDS:
fall of ground, ground control, roof falls, rock failure, mining induced seismicity

The ability to determine the location and timing of roof falls has been a long standing goal of safety professionals. The combination of microseismic monitoring and roof deflection measurements produces complementary information that more completely characterizes the pre-fall behavior of roof rock strata. This enhanced technology provides the kind of information needed by on-site personnel responsible for worker safety, to anticipate the occurrence of hazardous roof falls.

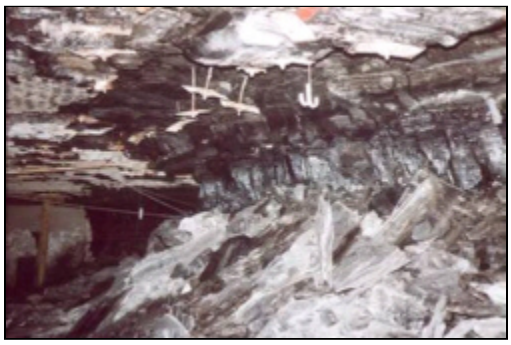
NIOSH is in the process of deploying several monitoring systems at mines with known roof fall problems so that an extensive database of microseismic emissions and roof-to-floor convergence and roof beam sag measurements can be established. These sites are from mines with varying geologies, stress conditions, and mining methods. It is recognized that several years will be needed to collect enough data to adequately prove or disprove the viability of this technology. In 2001-2003, several roof falls were monitored at an underground stone mine in southwestern Pennsylvania. In 2004, the microseismic database from the Moonee Colliery longwall coal mine in Australia was obtained and event trends were compared with roof fall occurrences. In early 2005, a South African microseismic monitoring system was deployed at an underground stone mine in northern West Virginia. In late 2005, a Canadian microseismic monitoring system is scheduled to be

deployed in a deep, steeply dipping stone mine in central Pennsylvania. In each case, monitoring will continue for 6 to 12 months and information on the geology, stress field, and mining methods will be collected. Additional field sites will be added in the future to continue to broaden NIOSH´s database.

Ongoing Research Project related to Ground Control

Ground Stability Through Advanced Mine Design

PURPOSE: This project seeks to reduce injuries and fatalities from ground falls in underground coal mines by developing state-of-the-art design tools for three related ground control problem areas: 1) deep cover coal pillar recovery, 2) high horizontal stress control and 3) multiple-seam mining.



Multiple-seam interactions can result in severe pillar loading and subsequent failure

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STRATEGIC GOAL:
Ground control

KEYWORDS:
underground mining, ground control, pillar recovery, horizontal stress, multiple seam mining

RESEARCH SUMMARY: In the 10 year period from 1995 through 2004, ground fall fatalities have averaged about 8 per year and accounted for almost 44% of all fatalities in underground coal mines. To meet increased coal demand, the industry must extract resources under more extreme and potentially dangerous ground control conditions. Interaction with stakeholders reveals three recurrent ground control problems in extreme conditions, namely, pillar recovery at depth, high horizontal stress control and multiple-seam mining.

Traditional room-and-pillar mine design methods used for shallow mines (less than 750 ft) do not work well in deeper mines. NIOSH researchers developed design guidelines for deep cover pillar recovery that reduce the likelihood of an uncontrolled roof collapse or a massive pillar collapse. The recommendations have been incorporated into the Mine Safety and Health Administration-approved Roof Control Plans at more than 100 operating coal mines throughout the United States.

The magnitude of maximum horizontal stress and whether it will induce mine roof damage under particular circumstances has remained elusive. NIOSH researchers found that horizontal stress in a mine roof depends on the roof rock modulus. A field study critically examined horizontal stress variation and displacements in a mine roof. Numerical models were created that simulated the observed behavior. NIOSH researchers developed a modeling procedure that uses sufficient geologic detail and the proper horizontal stress variation to create realistic numerical simulations of observed mine roof behavior.

The multiple-seam mining portion of the project is developing design tools for evaluating and controlling potential multiple-seam mining interactions using a combination of statistical analysis of a case history database and numerical models of the failure mechanics. Over 200 case histories of multiple seam mining interactions have been carefully documented. Sophisticated computer models are being utilized to understand the failure mechanics resulting from multiple seam mining. Development of rational multiple- seam mining guidelines that are based on the failure mechanics and the case history database is underway.

Some expected outputs from this work are:

1. Suggested guidelines for sizing coal pillars for recovery under deep cover.
2. Techniques for evaluating and controlling multiple seam hazards in underground mines.
3. Design methodology and guidelines for multiple seam operations.

Ongoing Research Project related to Ground Control

Guidelines for Eliminating Hazardous Ground Conditions From Underground Stone Mines

PURPOSE: Develop design guidelines for maximum roof spans and minimum pillar dimensions in underground stone mines. The effect of temperature and humidity on excavation stability will in addition be assessed and incorporated into the design guidelines.

RESEARCH SUMMARY: Fall of ground accidents have been the largest single cause of fatalities in underground stone mines in the decade 1994 through 2003, while the fall of ground injury rates have remained essentially unchanged since 1995. The room-and-pillar method is used in all underground stone mines. The dimensions of the pillars and the roof spans in these mines are largely based on past experience without consideration of the local geotechnical parameters that affect stability. A result is that roof falls can occur unexpectedly and pillar dimensions can be inadequate to support the overburden. In addition, anecdotal evidence seems to indicate that fluctuations in mine air temperature and humidity affect the stability of the roof and ribs. This project has the objective to develop an engineered approach to stone mine layout design so that ground fall accidents can be reduced or eliminated.

Roof fall caused by excessive horizontal stress in a limestone mine

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STRATEGIC GOAL:
Ground control

KEYWORDS:
fall of ground, stone mining, pillar design, roof span design, ground control

The research will largely be based on the statistical valuation of the performance of existing underground stone mine layouts. Field data will be collected at more than forty operating mines representing a variety of geological and operating conditions. The field data will be supplemented by monitoring of roof and pillar behavior at selected sites. Laboratory testing of rock strength properties and numerical analysis of roof and pillar failure mechanics will be conducted to better understand the mechanisms of failure and stability. These studies will provide statistical as well as analytically based results that identify critical parameters affecting stone mine stability. The results of the studies will be used to develop a methodology for designing roof spans and pillar dimensions in underground stone mines.

The outcome of the project will be guidelines for improved techniques for underground stone mine design resulting in the reduction of potentially hazardous ground conditions and improved safety of mine workers.

Ongoing Research Project related to Ground Control

Identification and Control of Rock Burst Hazards

PURPOSE: Reduce ground failure and injuries associated with rock bursts (earthquakes) in deep hard-rock mines.

RESEARCH SUMMARY: Mines in the Coeur d´Alene Mining District where rock-burst-related roof falls occur have a fatality rate eight times greater than the industry average for all causes of death. Ore from the platinum mines in Montana is being extracted from greater depths, and conditions that favor rock bursts are being encountered. Currently, five underground hard-rock mines in the United States have geologic and mining conditions that could generate rock bursts. These mines employed 2,239 (14%) of the 14,492 workers in metal/nonmetal mining.

Observing the damage to roof supports and rock following a rock burst

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STRATEGIC GOAL:
Ground control

KEYWORDS:
rock burst, underhand mining, seismic system

In the past, researchers at SRL have developed backfilling, destressing, and underhand mining to alleviate the hazards and protect miners from bursts. Currently, researchers are monitoring rock-burst prone mines to identify hazards before they become a problem. They have developed PC-based, in-mine seismic and electromagnetic monitoring systems to identify rock burst failure mechanisms and an Internet-based seismic monitoring system for real-time surveillance of seismic activity at targeted mines.

For example, wall strain and electromagnetic emissions are being investigated to determine if either can be used to develop a system that could warn of impending bursts. Partners in the research are the Stillwater Mining Co. (Stillwater and East Boulder mines); Hecla Mining Co. (Lucky Friday Mine); Coeur Silver Valley, Inc. (Galena Mine); the Montana Bureau of Mines and Geology, Office of Earthquake Studies; the Montana Tech Foundation; and Gonzaga University. Successful development of an early warning system could reduce injuries caused by rock bursts because miners could be evacuated to safe areas before a burst.

Ongoing Research Project related to Ground Control

Preventing Injuries from Falling Rock in Underground Coal Mines

PURPOSE: To reduce the risk of injury from rock falls by removing the barriers that limit the use of surface control technology. The barriers include: a lack of understanding of the geologic conditions that lead to small rock falls, a lack of knowledge about successful surface control techniques, inadequate installation procedures and equipment, lack of engineering design guidelines, and support and production costs.

Roof bolter advances his own protection using the Personal Bolter Screen (PBS) developed by NIOSH

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STRATEGIC GOAL:
Ground control

KEYWORDS:
underground mining, roof falls, roof fall injuries, roof support, ground control

RESEARCH SUMMARY: Each year, about 500 reported injuries (and usually 1-2 fatalities) result from relatively minor falls of rock from the roof in coal mines. These injuries occur in areas that have been supported and should be safe. Various surface control techniques are used in mines to control minor rock falls of the roof. However, current technologies are often ineffective, and they can be expensive and time-consuming to install. As a result, mine operators are often reluctant to use these technologies. This project is designed to reduce barriers to the use of surface control and improve the effectiveness of the surface control systems.

Research has identified the use of welded wire screen as the single most effective surface control to prevent rock falls between bolts. Dramatic reductions in injuries have been documented at mines that use screening on cycle. Routine use of screen is not common in coal mines. A number of installation "best practices" have been documented and are now being actively promoted in a series of underground screen installation demonstration sites. Another barrier to the adoption of roof screen is the perception that it is difficult to install and may, in fact, cause injuries. An ergonomics study using a simulated coal mine is being conducted to determine the ideal loads and positions related to transporting and installing screen. A training video that documents the benefits of roof screening has been developed and is currently being distributed.

Another project goal is to help identify rock types that are most prone to rock falls. Rock that is sensitive to moisture can deteriorate, swell, and fracture. Laboratory testing and down hole geophysical methods have shown promise in identifying weak rocks.

Some expected outputs from this work are:

1. Personal Bolter Screen technology for rock fall prevention
2. Training video: "Make It Safe with Roof Screen."
3. Ergonomic "best practices" for roof screen installation.

4. Suggested procedures for identifying weak, moisture sensitive rock prior to mining.

Ongoing Research Project related to Ground Control

Reduce Groundfall Hazards in Nevada

PURPOSE: Reduce groundfall injuries in Nevada underground mines excavated in weak rock masses. Develop new mining techniques using proven mine design techniques and adapting them to underground mines in weak rock.

RESEARCH SUMMARY: Underground mining is one of the most hazardous occupations worldwide. Most of the fatalities associated with underground mining are attributed to either groundfall or haulage. In the United States during the 1990´s, injuries and fatalities from falls of ground were an order of magnitude higher in mines excavated in weak rock masses than in underground mines in stronger rock (Mine Safety and Health Administration at www.MSHA.gov).

Portable Australian round-panel tester for fibre-reinforced shotcrete

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STRATEGIC GOAL:
Ground control

KEYWORDS:
shotcrete, stability, weak rock mass, design curves, rock mass rating (RMR)

To address the controlling and confounding factors involved in determining risk exposure in underground mines in weak rock masses, a twofold research approach was adopted. The first was to collect data to establish mine design criteria (rock mass ratings, span widths, and estimated loss of slough). The second was to study the use of fibre-reinforced shotcrete as a type of ground support. By conducting rigorous field tests and analyzing the data from the fiber-reinforced shotcrete used as immediate support at the Rodeo Mine, NIOSH personnel were able to provide information on new underground support design criteria that will lead to a safer working environment for underground miners.

Nevada Gold Book. An underground mine design manual for weak rock mass conditions in hard-rock mines has been developed. It contains information that relates span curves, rock mass rating (RMR) values, stope design curves, and ELOS values. This manual has been adopted at most mines in Nevada, Idaho, Montana, and Colorado.

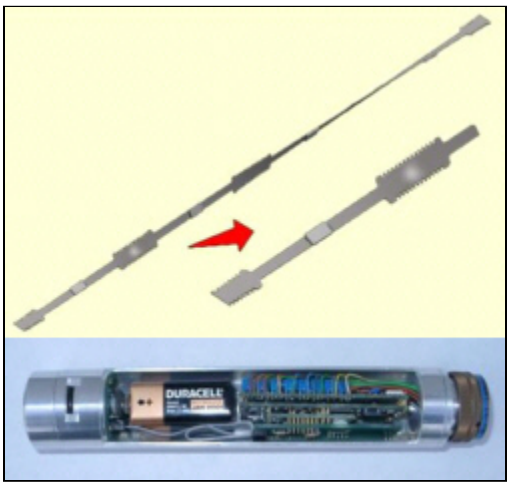
Shotcrete. NIOSH and the Barrick Gold Mining Company collaborated at Barrick's Rodeo/Meikle gold mines in Nevada to evaluate and compare the use of fibre-reinforced shotcrete to the use of steel screens with shotcrete. A field test of the two methods was conducted in a production test drift from May to October 2002. Analysis of test results by both Barrick and NIOSH SRL personnel confirmed a statistically significant improvement in ground control when fibre-reinforced shotcrete was used. Subsequently, Barrick decided to utilize fibre-reinforced shotcrete for 30% of its underground shotcrete applications.

Shotcrete Field Test. An Australian round panel test system was designed, built, and tested during FY04. This system gives mines the ability to test the strength of shotcrete in situ for immediate design and engineering parameters. Several mines have utilized these tests to improve underground support.

Ongoing Research Project related to Ground Control

Roof Fall Evaluation and Mediation in Weak Rocks

PURPOSE: Reduce the number of accidents and fatalities caused by mining in weak ground by developing accurate knowledge of how roof supports perform in weak rock, how fracturing is induced by excavation in weak rock, and how best to support adequately such ground or arrest the fracturing mechanism.



Top - Rock strain strip (ROSS); Bottom - Miniature data acquisition system (MIDAS)

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STRATEGIC GOAL:
Ground control

KEYWORDS:
roof support, rock strain, roof falls, numerical models

RESEARCH SUMMARY: Weak rock is a significant factor in roof falls, which are a leading cause of fatalities and injuries in underground mines in the United States. From 1998 to 2002, the incident rate for underground fatalities was 56.2 per 100,000 equivalent full-time employees ; falls of ground accounted for 43.3% of all underground fatalities. During the same period, the incident rate for nonfatal injuries and illnesses was 7.8 per 100 full-time equivalent employees; fall of ground accounted for 1.25 per 100 full-time equivalent employees.

It has been shown that borehole roughness affects anchorage capacity. Anchorage capability is especially critical in weak roof where the rock is especially prone to fracturing. In this project, researchers seek to address the question of whether borehole roughness can be measured with a simple device to indicate the anchorage capacity of a fully grouted bolt. In this regard, two new tools have been developed at NIOSH to study rock strength: a rock strain strip (ROSS) and a miniature data acquisition system (MIDAS). A ROSS is grouted into a borehole to measure strain in the roof of a mine opening. A MIDAS is used to read the strain sensors of a ROSS without the need for long cables to hook up to a computer. Research to date indicates that ROSS's are able to measure anchorage slip in fully grouted bolts.

Numerical models are being used to study failure mechanisms in weak rock. Therefore, this portion of the research project is directed to studying whether numerical models adequately simulate the fracturing mechanism. Results to date support this hypothesis, but further advances in discrete element modeling are needed to build the case. With models that simulate these observed failure mechanisms, researchers can determine if fracturing can be limited with rock supports to reduce the rock falls.

It is expected that this research will improve the performance of roof bolts in weak rock and determine ways to arrest or minimize the propagation of mining-induced fractures around an underground opening. Such improvements should increase stability around underground openings in weak rock and reduce the number of roof falls.

Ongoing Research Project related to Ground Control

Slope Stability Hazards Recognition

PURPOSE: Reduce injuries and fatalities associated with slope failures in surface mines and falls of ground in large underground openings.

RESEARCH SUMMARY: Slope stability research was focused to answer three specific questions.

Rockfall from highwall crushed operators cab on this excavator

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STRATEGIC GOAL:
Ground control

KEYWORDS:
surface mining, slope stability, hazard recognition, highwall, rock fall, backfill, rock fall, stability

- First, can new technologies be adapted to improve the recognition of mine slope hazards? One goal is to incorporate emerging technologies into tools that can provide more complete and more timely slope stability information. Emerging technologies include several remote-sensing techniques that can warn workers of hazardous rock slopes. Recorded data and images will allow study of rock falls and unstable ground. A hyperspectral imager developed at Carnegie Mellon Research Institute and an interferometric radar system developed in collaboration with Brigham Young University were tested in field trials at mine sites. Digital image analysis and real-time change detection using video technology have also been tested, demonstrating that rock displacements and falling rocks can be detected and recorded.
- Second, are there engineering solutions to reduce rockfall hazards by improving catch bench designs? Computer programs were developed in collaboration with Dr. Stan Miller, University of Idaho, to assess the effectiveness of a rock slope bench design to catch falling material. Functions and applications of the programs have been presented at professional conferences; more are planned. The software and a user´s guide will be made available in a NIOSH publication.
- Third, are there better ways to make miners aware of slope stability hazards? A training video was produced to address issues of mine slope safety. Taping was completed in 2003, and the video The Sky is Falling was released in 2004. Web-page material that will provide access to slope hazards information, published reports, and other materials will be published on the Internet.

Ongoing Research Project related to Ground Control

Stability Assessment with Seismic Monitoring

PURPOSE: Reduce hazards from rock mass instabilities in the underground mining workplace through (1) hazard mitigation studies that make use of seismic monitoring tools and (2) knowledge and technology transfer to industry.

RESEARCH SUMMARY: Rock bursts, coal bumps, and other large-scale dynamic failures represent serious ground control problems facing miners in certain industry sectors. These low-probability/high-consequence events often result in severe injuries or death and have the potential to affect an entire underground workforce. An inability to address these problems effectively can result in resource abandonment and/or mine closure and a significant economic impact on entire communities.

Installation of a remotely powered wireless seismic monitoring station

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STRATEGIC GOAL:
Ground control

KEYWORDS:
rock bursts, coal bumps, mine collapse, mining-induced seismicity, strata mechanics

Research personnel engage in joint projects with the mining industry using seismic monitoring tools to advance worker safety through several different avenues. These include (1) providing worker awareness of unusual ground response to mining, (2) forensic analyses of catastrophic failures, (3) guidance in rescue efforts, and (4) evaluation of hazard mitigation measures.

Several types of seismic monitoring systems have been developed and/or adapted for these different applications. They range from simple, low-cost, single-sensor seismic stations to sophisticated, multi-channel, wireless computer-network-based distributed data collection, processing, analysis, and display systems. Current project work involves a combination of technology transfer activities and ground control research. Project personnel are helping one western Colorado coal mine operator develop its own full-scale seismic monitoring network based on NIOSH´s wireless methods. The network will monitor seismicity in the vicinity of mine workings adjacent to an earthen dam and reservoir and will cover an area of approximately 50 square kilometers (20 sq. mi.). A temporary network will also be installed at a second Colorado coal mine in response to a request for assistance in characterizing mine-related seismic hazards at that property.

Data collected with these networks will be used to address the following research questions: (1) What are the failure mechanisms of damaging coal bumps and where do they originate? and (2) how close can mining approach a body of water and still avoid the hazards associated with dynamic rock mass failures?

Ongoing Research Project related to Surveillance and Training

Chemical Hazards in Coal Mining

PURPOSE: The purpose of this new pilot project is to evaluate the feasibility of using two existing information sources created pursuant to MSHA and US EPA regulations to update estimates of coal miners´ exposure to hazardous chemicals.

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STRATEGIC GOAL:
Surveillance and training

KEYWORDS:
mining, chemicals, exposure

RESEARCH SUMMARY: Very little information is available in the literature describing quantitative exposure assessment of chemical exposure of coal miners. No comprehensive evaluation of potential chemical exposures in the mining industry has been performed since data collection for the National Occupational Health Survey of Mining (NOHSM) was completed in 1989. The NOHSM inventory may be obsolete or incomplete due to changes in mining technology and waste management regulations that have created or changed potential exposure sources. Examples of potential exposure sources in coal mining include welding fumes, solvents, lubricants, and coal preparation chemicals. Some of these chemical agents are recognized as presenting acute and/or chronic toxicity. This lack of data is a significant data gap that impedes an adequate understanding of the occupational health risks of coal miners.

Nine mines with varying operational characteristics (surface/underground, small/large, preparation plant present) will be solicited to provide NIOSH with a copy of their hazard communication (hazcom) inventory list maintained pursuant to 30 CFR 47. A questionnaire requesting information about the mine´s waste management activities has been developed, reviewed and will be included in the solicitation. The most current EPA TRI reports will be downloaded for the same nine mines responding to the hazcom inventory solicitation.

Hazcom inventory information received from the selected mines and from the associated EPA TRI report will be compared to NOHSM chemical inventory data for the coal sector to determine if gaps exist. Information from the questionnaire on hazardous waste management practices and the EPA TRI data reports will be examined to identify any potential chemical exposures attributable to hazardous waste management activities.

Each collected data set (hazcom and TRI) will be qualitatively compared to the NOHSM chemical inventory data set and to each other to identify any change(s) in the type(s) of chemicals reported since NOHSM was completed. Successful utilization of these data sets will allow for an estimation of current chemical exposures in the mining industry. Also, any non-representation of chemicals between the two collected sets will be identified.

Ongoing Research Project related to Surveillance and Training

Chemical Hazards in Mining

PURPOSE: (1) Investigate and evaluate potential chemical hazards in mining workplaces, (2) develop control or mitigation methods for chemical hazard exposures, (3) develop new analytical methods to determine metal concentrations in mining workplaces accurately, and (4) communicate the health effects associated with chemical exposures to workers.

RESEARCH SUMMARY: Many mine workers are exposed to chemicals, dusts, mine gases, and welding fumes. Overexposure to these substances may cause significant acute or chronic health problems. Some chemicals cause acute injuries or illnesses such as dermatitis, burns, and poisonings. Others cause or contribute to chronic health problems such as heart or kidney disease or cancer. Chronic exposure to cadmium and lead are known to cause renal damage. Neurological dysfunctions can occur as a result of exposure to mercury, lead, cadmium, manganese, aluminum, and arsenic. In a study involving 1,400 welders from Alabama, 6% to 10% were found to have probable Parkinson´s disease, which was 7 to 10 times higher than would be expected in the normal population.

Fumes generated during welding

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STRATEGIC GOAL:
Surveillance and training

KEYWORDS:
chemical hazards, welding fumes, method development

Specific Aim 1: Can laboratory-based and field portable analytical methods be developed to determine metal concentrations accurately? The goal of this research is to validate laboratory-based analytical methods and develop field-portable methods that will provide near-real-time analyses for assessing workplace exposure levels to metals. Work was conducted to evaluate a method to differentiate between the quantities of water-soluble silver compounds and total silver collected on filters. Development of a method to measure manganese in the field using workplace air filter samples will be initiated this year.

Specific Aim 2: What is the quantity and nature of fume emissions generated from welding rods commonly used in mining? According to Bureau of Labor Statistics data (2002), an estimated 20% of all miners (24,655 miners) are exposed to potentially hazardous welding fumes. This work will involve (1) identification of welding rods and welding systems most commonly used in mining, (2) determination of welding fume formation rate, and (3) determination of the size and shape of fume particles as well as elemental composition of the fume.

Specific Aim 3: Can tools be developed to raise awareness of chemical hazards in the workplace? The HazCom Helper-MSHA version was released in 2003. Recognizing that at least 15% of customer requests were from nonmining companies regulated by OSHA, project researchers developed an OSHA version of the HazCom Helper. The HazCom Helper is a compliance tool (a CD) that enables companies with limited resources to meet the MSHA and OSHA requirements for the submission of written plans concerning hazardous products at their worksites.

Ongoing Research Project related to Surveillance and Training

Disseminating Safety and Health Interventions Via the Internet

PURPOSE: Develop methods for indexing content on the NIOSH Mining Safety and Health web site to improve customer access to that information.

RESEARCH SUMMARY: Documenting tax funded research is critical to our mission. The Internet is the most efficient and desired means for disseminating public information, but studies show that most federal web sites don´t disseminate information effectively. The NIOSH mining web site is no exception. The site currently consists of very broad topic pages which can contain hundreds of documents. Better indexing methods are needed to help our customers find information.

This project will use knowledge management techniques to index NIOSH mining web content. The ANSI/NISO/ISO Dublin Core standard will be used to track metadata for each web resource. A faceted thesaurus (adhering to ANSI/NISO Z39.19-2003) of standardized mining safety and health keywords will be developed. These keywords will be used to index web content.

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STRATEGIC GOAL:
Surveillance and training

KEYWORDS:
mining, safety, health, knowledge management, Internet

In the short term, this work will improve customer access to our web-based safety and health information. We´ll be able to guide customers through interrelated web content in an organized manner, as well as improve accuracy of free text searches. Cataloging our web resources will also improve web site maintenance. We´ll be able to track what type of content we have or don´t have, who is responsible for maintenance, date of last review, etc. We´ll also be able to identify more precisely the type of information that is most requested by our customers.

At the same time, this work is being designed for compatibility with emerging web technologies and activities of the World Wide Web Consortium (W3C). These new technologies are being developed to support a future "Semantic Web" which, if realized, will improve web resource discovery worldwide.

The result will be a new mining web that provides easier access to and dissemination of NIOSH´s mining health and safety research knowledge database.

Ongoing Research Project related to Surveillance and Training

Education and Training for an Evolving Mining Work Force

PURPOSE: To assess safety and health training needs for a demographically changing mining workforce and develop appropriate related interventions.

RESEARCH SUMMARY: NIOSH stakeholders stated they anticipate a change in the mining workforce in the United States within the next decade. An entire cohort of miners in the current workforce is aging and replacing them will require an influx of new miners. This phenomenon presents an opportunity to study a workforce on the cusp of change and to discover the training and communication needs of two different but interrelated demographic groups.

Specific project tasks are to (1) conduct a demographic assessment of the frequency and types of injuries of the various age groups of miners, then tailor health and safety messages to any significant differences that may exist between age groups, (2) create and assess procedures to ensure the provision of consistent health and safety messages to miners during workforce transitions, (3) develop a protocol for capturing and transferring the knowledge of experienced miners to new hires, and (4) assess age and experience related differences in acceptance of training technologies, and explore ways these differences (if any) can be positive factors for the delivery of coherent programs.

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STRATEGIC GOAL:
Surveillance and training

KEYWORDS:
mining, training, effectiveness research

As of February 2005 this project has resulted in the publication of 15 documents and 33 presentations addressing the four project tasks listed above. (1) Data confirmed that the mining industry is in a time of changing demographics and injury experience is different for miners in different age categories. (2) A process for job procedure documentation was developed to lessen variability during knowledge transfer. (3) An on-the-job training program was created to improve passing information from experienced miners to new employees. (4) Learning preference differences between older and younger employees is reported in the literature, but an across the board preference for active learning (hands-on practice, simulation, etc.) was found at mine sites. Two seminars were also developed to provide professional development opportunities for safety and health training professionals and on-the-job trainers. Both translated adult education theory into practical strategies that can be used to train miners of any age. A computer-based training intervention for training new miners in map reading skills is under development. These project outputs will result in a better trained and therefore safer mining workforce.

Team members from the Pittsburgh and Spokane Research Laboratories have worked with partners from Twentymile Coal Company, Pennsylvania Services Corporation, J.H. Fletcher and Company, Morton Salt, Rurher´s Quarry, the State of Pennsylvania Department of Environmental Protection, and the Mine Safety and Health Administration to conduct the work of this project.

Ongoing Research Project related to Surveillance and Training

Evaluation of Heat Stress and Interventions in Surface and Underground Mines

PURPOSE: Determine if a relationship exists between overexposure to heat during mining and other related activities and increased risk of injury.

RESEARCH SUMMARY: Previous research by MSHA in 1976 and 1986 identified mine work environments as presenting a significant potential for exposures to heat in excess of the NIOSH criteria document for this stressor. The use of diesel equipment in these underground environments has increased since those studies were conducted with a concomitant increase in heat exposure.

Mine operators recognize high heat as an impediment to performance. Heat strain can result in diminished strength, judgment, skills, and safety awareness, which could be manifested as increased incident rates in work areas. A double fatality due to heat stroke occurred in Nevada in 2002 and resulted in increased interest in evaluation and prevention research.

The questions addressed in this project are (1) what are the heat stressors and the resulting strain among underground and surface miners? (2) are interventions currently available to reduce thermal stressors in hot mining environments effective? and (3) can a means be developed to monitor the physiologic status of at-risk miners in real time.

Members of a mine rescue team wearing masks and other gear that can lead to an increased heat burden

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STRATEGIC GOAL:
Surveillance and training

KEYWORDS:
heat stress, emergency response, mining, heat illness, intervention effectiveness, ergonomics, exposure assessment, prevention

To address these questions, the approach taken was to (1) identify and quantify the sources of heat in mine work environments, (2) measure the temperature response of workers to hot environments, (3) evaluate the most promising interventions to reduce the effect on the miners, and (4) transfer research results and technologies to the mining industry.

The investigative approach focuses on measuring exposure levels concurrent with monitoring miners' responses to their environment in terms of heart rate and core body temperature. Effectiveness of interventions will be evaluated by comparing the core temperature response of a miner to conditions with and without interventions. In addition to production workers, research will examine the heat load of emergency responders who are exposed to hot environments while wearing breathing apparatuses.

Ongoing Research Project related to Surveillance and Training

Hazard Evaluation and Technical Assistance

PURPOSE: Provide flexibility in technical assistance within a framework that allows researchers to identify latent or emerging hazards.

RESEARCH SUMMARY: A mechanism is needed to permit topic experts to conduct evaluations and provide technical assistance in response to stakeholder concerns that arise from an immediate hazardous or unhealthy situation. Recent examples of technical assistance include (1) collaboration with a Pittsburgh Research Laboratory project in which noise controls presently available in Western metal/nonmetal mines were reviewed, (2) an evaluation of the possible causes of a high incidence of dermatitis in miners in an underground gold mine operation, (3) an assessment of the proposed respiratory protection program for workers during the next phase of construction of the Yucca Mountain Nuclear Repository, and (4) an evaluation of the health risks associated with naturally occurring hydrocarbon seeps in a Western underground coal mine.

NIOSH investigator measures sound intensity levels at a talc mill

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STRATEGIC GOAL:
Surveillance and training

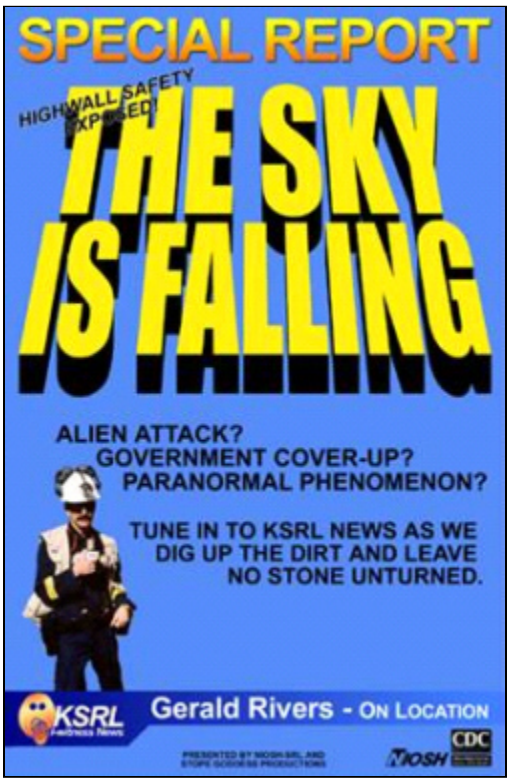
KEYWORDS:
mining, engineering controls, intervention, hazard assessment, technical assistance

Currently, research is based on long-term strategic planning and successful completion of intermediate goals. In this project, personnel will take advantage of geographic location, topic expertise, and stakeholder awareness. The project will provide flexibility to respond to requests from the mining workforce, other government agencies such as the Mine Safety and Health Administration (MSHA) and the Occupational Safety and Health Administration (OSHA), and NIOSH researchers who identify issues of concern based on health and safety statistics or other information. Results will include the development of new project ideas and identification of areas of needed research, as well as formulation of partnerships to implement and evaluate intervention strategies.

Ongoing Research Project related to Surveillance and Training

Health Communications Program

PURPOSE: Provide health communications services and guidance to SRL and PRL researchers to facilitate the continuous exchange of information and to translate research results to the widest range of customers.



RESEARCH SUMMARY: Developing a technical solution to an occupational safety and health problem will not, in itself, result in reduced injury and illness in the workplace. Instead, it is the adoption of the new device, information, or process that can have an impact. Adoption of such items requires that individuals, somewhere in the industry, change the way that they do their jobs. As such, NIOSH mining research products and information must be adopted by industry and individuals if the research is to make a difference in worker safety and health. Causing industry to adopt safer and healthier work methods is complicated by the products and by the audience. Research to improve worker safety and health is broad-based by its nature, spanning all segments of industry and the population. Research findings that can reduce injury and illness in the workplace also take many forms including new machines, processes, and knowledge. In addition, each product, target population, and application presents different barriers to adoption, requiring tailored approaches to cause change in the target population and adoption of the research results. While many researchers have earned respect among peers for their work, it can be difficult for them to fully translate research results into products or messages that are understandable or useful to a wide range of customer groups. The Health Communications teams at SRL and PRL assist in the effective transfer of research results to diverse segments of the mining and scientific communities so that they are useful to and used in the workplace.

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STRATEGIC GOALS:
Cumulative injuries; Ground control; Hearing loss; Mine disasters; Respiratory diseases; Surveillance and training; Traumatic injuries

KEYWORDS:
health communication, marketing, technology transfer, r2p, public information, outreach

The Health Communications program is made up of three components: research-to-practice education and implementation, public outreach and technology transfer, and social research that includes such issues as effective training methods, adult learning theories, evaluation of qualitative data, and the effect of socio-economic issues on mining operations. The overarching goal of this program is to facilitate the adoption of new research findings and products developed at SRL and PRL.

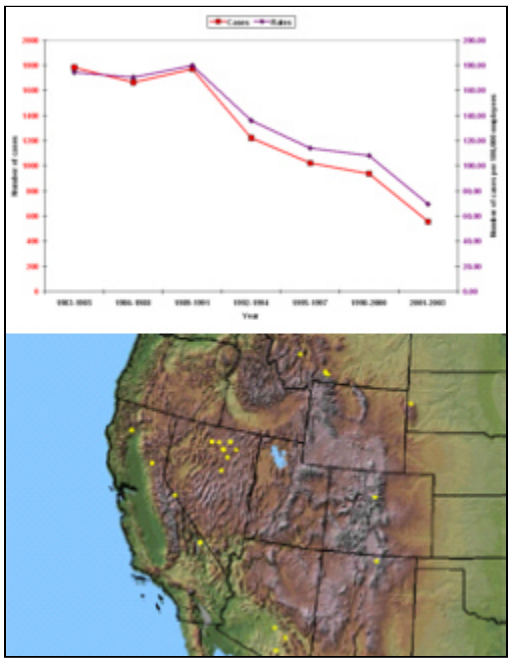
Ongoing Research Project related to Surveillance and Training

Surveillance of Mine Safety Hazards

PURPOSE: Provide surveillance services, data management, and outcome evaluation guidance to SRL researchers to help ensure that research decisions and directions are evidence-based and in agreement with NIOSH goals and stakeholder priorities. Examples include the development and demonstration of geographical information system (GIS) methodologies for spatially mapping and analyzing accident and occupational disease information.

RESEARCH SUMMARY: Surveillance as a public health component has a long and distinguished history. CDC and NIOSH have recognized the importance of surveillance in overall program design and in weighing the evidence to ensure that priorities are meaningful. The Surveillance program at SRL is intended to assist in the identification of problems and hazards in the mining and construction industries, and to assist in evaluating the impacts and outcomes of the research programs. The SRL Surveillance team collaborated with Institute-wide surveillance workers to produce a strategic plan for NIOSH surveillance.

Analysis of severe mining injuries (fatal or permanently disabling) shows that over the period from 1983 through 2003, substantial declines have occurred in both the number of cases and the incidence rates. Additional analyses are underway to further detail these declines. In particular, the aging of the mining population may be a major factor in that experienced miners have reduced risk of injury. The patterns shown below will be age- and experience-adjusted to better delineate these influences. A survey of the demographics of miners is being conducted which will aid such analyses greatly.



Top - 3-fold reductions in incidence of fatal and permanently disabling injuries have been reported over the 21-year period shown; Bottom - Spatial attributes of western underground metal mine locations with injuries suggest remoteness from urban centers

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STRATEGIC GOAL:
Surveillance and training

KEYWORDS:
surveillance, reported case data, injury and illness burden, data management, risk assessment, risk management, statistical and epidemiological data analysis, geographic information systems.

A key component of SRL´s approach is the use of geographic information systems (GIS) and methods to enhance the utility of mining injury and illness data. The spatial distribution of mining injury and illness events enters the surveillance outlook in many ways, including:

- The use of maps to identify locations for candidate mining research projects
- Associating geologic factors with potential mining fall-of-ground exposures

- Identifying states, districts and regions with clusters of injuries of specific type
- Identifying hospital cachement areas vs mine locations to facilitate rescue efforts and limiting the consequences of severe injuries

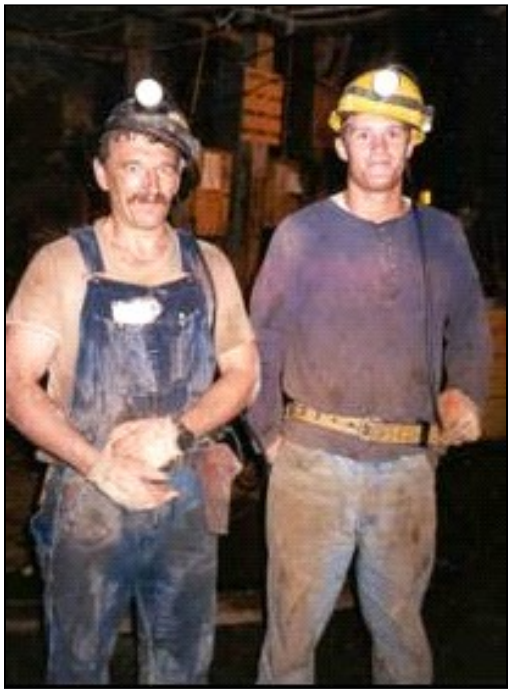
The map shown suggests that mine disasters may have consequences that are exacerbated because of the remote locations and lack of access to emergency response, rescue efforts and treatment centers.

Ongoing Research Project related to Surveillance and Training

Surveillance: National Survey of the Mining Population

PURPOSE: To improve the National Institute for Occupational Safety and Health´s (NIOSH) surveillance capability related to the occupational risks in mining by conducting a national survey of mines and mine employees.

RESEARCH SUMMARY: Due to the lack of up-to-date, appropriate, and accurate information for mine employees, NIOSH is undertaking a national survey that will provide demographic and occupational information for the mining population. The last survey of mine operator employees, the Mining Industry Population Survey (MIPS), was conducted by the U.S. Bureau of Mines in 1986. The mining industry has experienced many changes since the MIPS was conducted, thus this information is now too outdated to be considered useful for surveillance on the current mining workforce. Other available national surveys such as the Current Population Survey (CPS) and the Census 2000 are not very useful for mining industry surveillance because they do not differentiate between underground and surface workers or between direct employees and contractor personnel. Additionally, CPS and Mine Safety and Health Administration (MSHA) industry and occupational coding systems differ which leads to incompatibility for specific commodities, work locations, and work activities.



Miners from the Galena Silver Mine, Idaho

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STRATEGIC GOAL:
Surveillance and training

KEYWORDS:
surveillance, mining, databases

The National Survey of the Mining Population will be a survey of mines and their employees for each of the five major mining sectors (coal, metal, nonmetal, stone, and sand and gravel). The major objectives of the survey will be to: (1) collect some basic information about mining operations; (2) establish the demographic and occupational characteristics of mine operator employees within each mining sector; and (3) determine the number and occupational characteristics of independent contractor employees within mines.

The most important goal of this study will be to obtain denominator data so that the MSHA Accident, Injury, and Illness Report (MSHA Form 7000-1) can be evaluated in relation to the population at risk. Currently, MSHA collects data on the work location where the incident occurred, and the demographics of the injured or ill miner. Demographic and occupational data on the overall mining workforce are not collected. As a consequence, the accident data cannot

be fully exploited to study the employee-level correlates of mining accidents. The National Survey of the Mining Population will collect employee-level data that can be used to create the denominator data needed to construct accident rates for various demographic groups that reflect the population at risk.

Ongoing Research Project related to Surveillance and Training

Workplace Stress Among Underground Coal Miners

PURPOSE: Reduce health problems for miners resulting from workplace stress by examining the relationship between workplace stress in the underground coal mining industry and the salivary cortisol response to awakening (SCRA).

Worker installing a roof bolt at an underground coal mine

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STRATEGIC GOAL:
Surveillance and training

KEYWORDS:
stress, underground mining, biomarkers

RESEARCH SUMMARY: Workplace stress has been linked to increased risks for cardiovascular disease, depression, and musculoskeletal disorders. The mechanisms by which stress affects health are not established, but research suggests that they may involve maladaptive changes in the hypothalamic-pituitary-adrenal (HPA) axis, the physiological system responsible for regulating the stress response.

This study will evaluate one measure of HPA axis function, the salivary cortisol response to awakening (SCRA), for use as a potential biomarker for workplace stressors in underground coal mine workers. The SCRA will be assessed by measuring cortisol levels in a series of saliva samples obtained by subjects during the first hour after they wake in the morning. The SCRA is reported to be a reliable marker of the function of the HPA axis. Although the SCRA has been used in studies of workplace stressors, research to date has been limited by 1) small sample sizes; 2) measurement error due to subjects´ failure to obtain samples at the specific times required in the protocol; 3) measurement error due to the use of immunoassays with insufficient specificity for cortisol; and 4) inadequate assessment or control of confounding factors, including light exposure, time of awakening, duration of sleep, body mass index (BMI), and alcohol intake. This project will collect measurements of the SCRA using a much larger group of subjects (target of 400) than previous research. A sample of subjects will be monitored for compliance with the saliva sampling protocol, using an electronic monitoring device that was developed for monitoring compliance with taking medications. Human Subjects Review Board and Office of Management and Budget approval for the project has been received. It is anticipated that annual safety refresher training classes for miners will be attended by NIOSH personnel to solicit participation from miners. One such trip has been completed and an initial set of samples collected.

Successful project completion will result in: the development of a biomarker for chronic workplace stress, which can be used to screen workers under chronic stress and identify those at high risk of developing adverse health outcomes, and the development of a training module on workplace stress which can be used by mine trainers to teach miners about the effects of stress and what they can do to reduce stress.